COOPERATION

COOPERATION AGREEMENT ON MINERAL DEVELOPMENT

Program and Summaries, Fifteenth Annual Open House and Review of Activities

D.R. MacDonald, Editor

Nova Scotia Department of Natural Resources
Report 91-5

Canada

Nova Scotia

Province of Nova Scotia

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Nova Scotia

Department of Natural Resources

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Minister

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Deputy Minister

Halifax, Nova Scotia
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REVIEW OF ACTIVITIES

The Mines and Minerals Branch of the Nova Scotia Department of Natural Resources is holding its Fifteenth Annual Open House and Review of Activities on Wednesday and Thursday, November 20 and 21, 1991. All activities will be held at the Lord Nelson Hotel, Halifax.

This year's Open House and Review of Activities will focus on the programs of the Canada - Nova Scotia Cooperation Agreement on Mineral Development.

Poster displays prepared by departmental personnel, the Geological Survey of Canada, Energy, Mines and Resources Canada, and Nova Scotia universities will be open for viewing from 18:00 to 23:00 on Wednesday and 8:00 to 16:00 on Thursday.

Highlights of the poster displays will include: preliminary results of a four-hole diamond-drilling program to study metasediment-hosted Sn-Zn-Cu mineralization at the Dominique deposit in Yarmouth County; open file maps of aggregate potential in Colchester and Cumberland Counties; demonstrations of the Department's use of mine-planning software; and free bibliographic reference searches using the GEOSCAN database.

The Department invites you to attend a luncheon on Thursday, November 21. The Minister of Natural Resources, The Honourable C. W. "Chuck" MacNeil, M.D., will be the guest speaker. The cost of the luncheon is $11.00 per person and will feature Horatio's Buffet.

The Open House and Review of Activities provides an opportunity to view the results of work in the earth sciences in Nova Scotia, to learn the current status of mineral and energy exploration, and to meet and consult with members of the Department.

PROGRAM

Wednesday, November 20, 1991

18:00 to 21:00	Registration
18:00 to 23:00	Displays Open
19:00 to 23:00	Reception, Cash Bar

Thursday, November 21, 1991

08:00 to 12:30	Registration
08:00 to 16:00	Displays Open
09:00 to 09.10	Greetings and Introduction: Pat Phelan
09:10 to 09:20	Overview of Energy Resources Division activities: Andrew Batcup
09:20 to 09:40	Overview of Federal activities on the Canada - Nova Scotia Cooperation Agreement on Mineral Development: Al Sangster
09:40 to 10:00	Overview of Provincial activities on the Canada - Nova Scotia Cooperation Agreement on Mineral Development: Dan Murray
10:00 to 10:30	BREAK
10:30 to 11:00	Carboniferous mineralization - Where do we look now?: Bob Ryan
11:00 to 11:30	Overview of Pb-Zn mineralization at the Gays River deposit: Dan Kontak
11:30 to 12:00	Application of multi-media exploration geochemical techniques at the Yava Pb deposit, southeastern Cape Breton Island: Mike MacDonald
12:00 to 12:20	Questions and Comments
12:30 to 14:00	LUNCHEON and Speaker, Honourable C. W. "Chuck" MacNeil, M.D., Minister of Natural Resources
16:00	Open House Closes

ASSISTANCE FOR YOU

The Department of Natural Resources, Mines and Minerals Branch, welcomes you to the 1991 Open House and Review of Activities. Our staff will be pleased to assist you with private consultations or in locating information.

Our library has a wide variety of publications, maps, journals, textbooks and assessment reports. The core library has over 500 000 m of drill core from industry and departmental drillholes.

We offer our assistance at no charge and we encourage you to use our services. Here are telephone numbers and FAX numbers for various groups within the Department.

Mines and Minerals Branch Administration
(902) 424-5346; FAX (902) 424-7735
Mineral Resources and Geological Mapping
(902) 424-4700; FAX (902) 424-0527
Public Awareness and Education
(902) 424-7199; FAX (902) 424-7735
Mineral Development, Industrial Minerals,
Land-Use Planning, and Mineral Inventory
(902) 424-4162; FAX (902) 424-7735
Library
(902) 424-8633; FAX (902) 424-7735
Mineral and Petroleum Rights
(902) 424-4068; FAX (902) 424-7735
Mining Engineering
(902) 424-5764; FAX (902) 424-7735
Coal and Petroleum Resources
(902) 424-4575; FAX (902) 424-7735
Regional Office and Exploration Monitoring:
Stellarton
(902) 752-8429; FAX (902) 755-3158
Core Library: Stellarton
(902) 752-4842; FAX (902) 755-3158

CONTROLS ON ANCIENT PEAT ACCUMULATION IN THE SPRINGHILL COALFIELD: IMPLICATIONS FOR COAL EXPLORATION IN THE CUMBERLAND BASIN

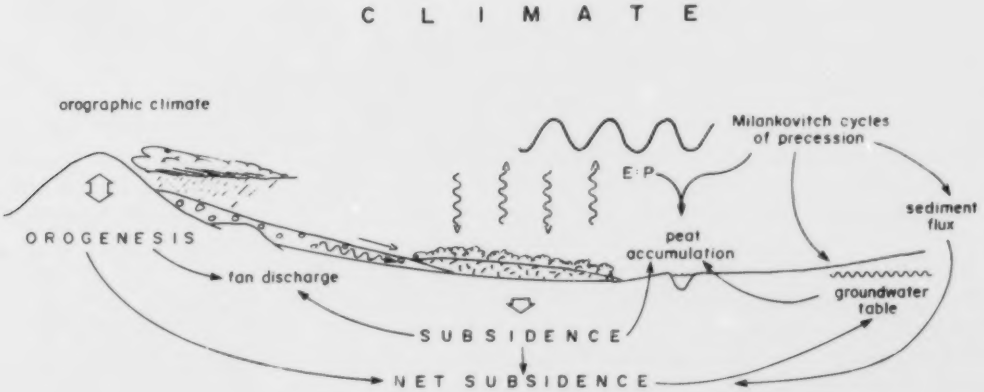
J. H. Calder

During the past four years, research has been conducted into influential controls on the formation of coal deposits at Springhill, the thickest seams known in the Cumberland Basin. An understanding of these controls focuses the search for new coal deposits on areas of the basin where these prerequisite conditions existed some 300 million years ago.

During the early Westphalian, tropical peatlands (mires) flourished along the southern margin of the intermontane Cumberland Basin in present-day northern Nova Scotia. These were rheotrophic (flow-fed) peatlands, fed by nutrient-rich groundwater emanating from alluvial fans. Evidence includes the consistent relation between coal seams and basin-margin conglomerate units, the incursion into the mires of distal fan sheetfloods, trends in lithotype and maceral composition of the coal (especially gelification of vitrinite macerals), and the domination of mire flora by arboreous lycopsids suited to areas of nutrient-rich groundwater influx.

A number of controls interacted to influence the development of the peat-forming ecosystems. Tectonism exerted a major control at the basin-fill sequence level (10^6 yr) through both extremely rapid subsidence and orogenesis, but was inextricably linked to climate. The resulting alluvial fans discharged nutrient-rich groundwater, which in modern sub-humid settings is crucial to the maintenance of wetlands in drier periods. Progressive denudation of the adjacent Cobequid Highlands resulted in a decreased catchment area, orographic rainshadow and fan size, and may have contributed to the progressive decline in peat accumulation. The 600 m thick coal window identified within the basin-fill sequence is inferred to reflect a coincidence of optimal groundwater supply and net subsidence. Cyclothems (nonmarine, 20-30 m thick) indicate that conditions favouring peat accumulation recurred with a cyclicity in the order of 10^4 yr. The similar time frame of Milankovitch cycles of obliquity and precession suggests that climatic or related (eustasy, geoid) change was influential in cyclothem and mire development; numerous external and intrinsic processes have been identified which operated over shorter time frames. The resolution of time, fraught with assumption, is nonetheless crucial to the understanding of controls on the development of such ecosystems, and resulting coal deposits.

So compelling is the evidence for the requirement of supplemental groundwater discharge from mature alluvial fans, that it is unlikely that thick coal seams will be found far removed from fanglomerates. The tectonic setting required is one in which fan progradation was minimal, as in an extensional or transcurrent setting.



COMPUTER MODELLING OF THE SYDNEY AND PICTOU COALFIELDS USING GEOMODEL - AN EXPERT SYSTEM FOR LAYERED GEOLOGICAL ENVIRONMENTS[1]

J. D. Hughes[2] and D. J. MacNeil

Computer databases have been developed for the Pictou and Sydney coalfields through a cooperative project between the Geological Survey of Canada and the Nova Scotia Department of Natural Resources, funded by the first and second Canada - Nova Scotia Mineral Development agreements. These databases contain all verifiable geological data available for these coalfields, including information from digitized topographic and geological maps, surface outcrops, subsurface drilling, mine workings and laboratory analyses. The Sydney coalfield database, for example, contains information from 800 boreholes, 150 surface outcrops, 4500 channel samples and 30,000 analyses; whereas the Pictou database contains information from 400 surface outcrops, 410 boreholes and 5000 laboratory analyses. Remotely sensed Landsat Thematic Mapper data have also been incorporated for both coalfields.

Geological information within the databases for each coalfield is entered into GEOMODEL, which creates a three-dimensional digital model defining the geometry of coal beds, faults and other geological surfaces in each area. GEOMODEL is an expert system developed over the past few years by the Geological Survey of Canada for modelling layered sequences. The system incorporates a full range of multiple-surface logic, and develops digital grid models which can be used to assess the geology, economics and resource quantities contained within such sequences. This system, which runs on a large superminicomputer, allows the graphical display of modelled data in map and cross-section form, the prediction of intersections in future wells at any point in a model, and a full range of volumetric capabilities to assess the economics of a deposit. The system also interfaces with microcomputer-based applications software including a Geographic Information System (GIS), a three-dimensional Computer-Aided Design (CAD) system, and an image-processing system, which provide extensive additional query, display and data integration capabilities.

The accompanying poster display illustrates some of the outputs available from the system. Both the Sydney and Pictou coalfields are in the final phases of computer modelling, and hence some of these displays will change as the models are subsequently refined. Comprehensive publications, which will present displays and analyses based on the final models, are planned for 1992. Outputs from this work will also be available in digital format, including both the primary geological data, which have been installed at Nova Scotia Department of Natural Resources, Halifax, in a microcomputer-based ORACLE database, and the completed grid models, which can be output in ASCII or GIS-compatible formats.

1 Funded under the Canada - Nova Scotia Cooperation Agreement on Mineral Developemnt 1990-1992

2 Geological Survey of Canada, 3303-33rd Street N. W., Calgary, Alberta T2L 2A7

ACTIVITIES OF THE PETROLEUM RESOURCES SECTION

D. J. MacDonald

The Petroleum Resources Section has been busy in both the onshore and offshore areas during the last reporting period. Commencement of the first offshore petroleum development in Atlantic Canada highlighted the section's responsibilities for management of the offshore resource. Work in coalbed methane, geophysical modelling in one of Nova Scotia's coal basins, monitoring the numerous activities of the offshore development, and establishment of a royalty regime for the Cohasset-Panuke oil project have involved considerable staff time. Promotional efforts have resulted in representation at several oilfield conferences, technical presentations, and the release of several publications. Regulatory aspects of both the onshore and offshore have involved staff in the drafting, review and implementation of acts, regulations and guidelines.

ONSHORE PETROLEUM ACTIVITY

The consortium of New World Ventures, FarAway Resources, and Bird Oil has continued exploration efforts to evaluate the petroleum potential of their holdings in the Minas Basin area. The consortium is in the second year of their exploration agreements, which require that a seismic program or other such work be conducted upon their lands. The third year work commitment requires the drilling of a well on each of the three parcels of land. Consultants AGREN has renewed its exploration agreement in the Minas Basin area for a second term of three years. During the first term a seismic program was run and an exploration well was drilled.

A source rock study has been completed by the department. This study characterises the ability of various stratigraphic units to have acted as petroleum source rocks.

Coalbed methane is becoming an exciting new opportunity for petroleum exploration in the province. Coalbed methane exploration and development are regulated under the Petroleum Resources Act in Nova Scotia. Petroleum Resources Section staff have begun work in conjunction with the Coal Development Section on geological aspects of coalbed methane (see abstract on Coalbed Methane, this volume). Geophysical modelling of the coal basins has been initiated. Drilling technology and completion techniques are being reviewed in consultation with other jurisdictions. The Petroleum Resources Act defines petroleum to include "coal gas". To explore for coal gas in Nova Scotia, interested parties must enter into a Coal Gas Exploration Agreement with the province. Preparation for rights issuance will continue into the next year and cooperative ventures with industry and research agencies are anticipated.

OFFSHORE ACTIVITY

There has been a variety of activities in the offshore region as well. Three geophysical programs have been conducted on their respective lands in the offshore, one by Mobil, one by LASMO and the other by Nova Scotia Resources Ltd. LASMO and Nova Scotia Resources Ltd. drilled two wildcat wells during the last year to test look-alike features to the Cohasset field. The well drilled at the Lawrence structure was unsuccessful, whereas the Balmoral discovery found oil in a number of zones. LASMO and Nova Scotia Resources Ltd. made significant progress toward development of the Cohasset-Panuke oil fields to the west of Sable Island. Geotechnical and seabed survey work combined with seismic work over the two adjacent fields were completed. Installation of a template at Panuke permitted the commencement of development drilling. Construction and fabrication of the major components of this project were completed by August 1991 and all the components for the project were installed during August and September 1991. The drilling unit, the Rowan Gorilla III, has undergone modifications with the installation of equipment to outfit it as a production facility. The production unit will proceed to the project area in early November to ready the fields for an April 1992 production startup.

COALBED METHANE: AN IMPORTANT RESOURCE FOR NOVA SCOTIA?

D. J. MacDonald, R. D. Naylor, J. H. Calder, P. J. Harvey and M. S. McPhee

Coalbed methane has been traditionally regarded as a dangerous by-product of coal mining. Considerable effort has been given to venting it from mine workings. This unfortunately contributes to the greenhouse effect. Over the last ten years or so there has been an aggressive effort in the United States, and more recently in western Canada, to develop coalbed methane as an energy source. A recent preliminary estimate puts the methane potential of Atlantic Canada at some 38 million cubic metres (1.34 trillion cubic feet). Nova Scotia has the greatest share of the region's coal resources and, therefore, the associated methane.

The Nova Scotia Department of Natural Resources is currently assessing the coalbed methane potential of Nova Scotia. Work to date has focused on data collection and information gathering on a wide range of topics related to coalbed methane, including: the geology of the coal and coal basins, geological modelling, coal chemistry, coal rank and gas desorption data, and information on current technology. Results of this work are expected to be comprehensive databases, cross-sections and maps. Resource estimates will rely on gathering coal desorption data for as many seams as possible. Cooperative ventures with industry and research agencies are anticipated.

Several areas with significant coalbed methane potential include:
(1) the Sydney coalfield where a number of mine workings continue to liberate considerable quantities of methane;
(2) the Springhill coalfield where, ahead of the former mine workings, a number of seams would likely yield significant quantities of methane; and
(3) The Pictou coalfield (Stellarton Basin), which contains a large number of relatively thick seams at various depths.

RECENT RESEARCH IN THE SYDNEY COALFIELD

D. J. MacNeil, R. D. Naylor and J. White[1]

Planning for underground coal mines usually requires detailed surface drilling in advance of workings. Unfortunately, the mines of the Sydney coalfield underlie the Atlantic Ocean, making extensive drilling impossible. To predict mine geology, geologists from the Cape Breton Development Corporation (CBDC) require as much information as possible about the coal seams and associated strata. The Coal Section of the Nova Scotia Department of Natural Resources, Dalhousie University, the Institute of Sedimentary and Petroleum Geology, and CBDC are currently working cooperatively on a number of projects intended to assist with modelling mine geology in the Sydney coalfield. These projects include: (1) a study of the regional stratigraphy of the Harbour seam and its roof and floor rock, (2) an investigation of the use of organic petrography as a guide to coal seam thickness and quality, (3) a study of the controls on deposition of sandstone-dominated sequences above coal seams (see abstract by Gibling *et al.*, this volume) and (4) research into the relationship between the occurrence of limestone in the roof of coal seams and changes in seam thickness and sulphur content.

1 Dalhousie University, Department of Geology, Halifax, Nova Scotia B3H 4J1

AUTOMATION IN THE MINERAL DEVELOPMENT DIVISION[1]

L. Crust

BACKGROUND

The development and use of computer applications within the Mineral Development Division has continued to progress over the past year. The Halifax office local area network currently has fourteen workstations, consisting of nine workstations within the Mineral Development Division, three in the Mining Engineering Division, one in the Energy Resources Division, and one in the Finance and Administration Division. The Stellarton office has a total of four stand-alone microcomputers. During the coming year we expect to upgrade our network operating system from Novell Netware 2.15• to Novell Netware 3.11•, and to increase the hard disk capacity of the network. Major applications for computers remain database management (using Advanced Revelation•), word processing (using WordPerfect•), communications (using Pibterm•), spreadsheet (using Lotus 123•), and business graphics (using Harvard Graphics•). We are also beginning to implement a system of office automation using WordPerfect Office 3.0•.

WORK IN PROGRESS

Work is continuing on the development of an automated system of record keeping for the Registry of Mineral and Petroleum Titles. Databases for storing information on applications, licenses, leases and transfers are now in use, and it is anticipated that the search of title involved in title registration will soon be performed by automated routines on the computer. The Industrial Minerals Group has begun to develop an industrial minerals database with some entries on gypsum/anhydrite and aggregates. Rockware• software is also being used for drill log plotting. The Land-Use Policy Development Project has been building a number of databases. Most notable among these are the aquaculture database, containing information relating to applications for aquaculture licenses, and the map references database, which contains information on minerals, energy and aggregate resources, landforms, land use, and drillholes for each map sheet. The Mineral Inventory Group has been working on developing a metallic mineral occurrences database and a database of information on geological, geochemical and geophysical maps. Work has also been done on copying the Nova Scotia component of the GEOSCAN database in Ottawa to a database on our local area network.

The Library now has automated systems for its card catalogue and inventory of publications. All new acquisitions are entered directly into the computerized system, and acquisition lists and books of Library holdings are generated automatically. Similarly, information from library service slips, relating to the distribution of publications as well as the use of other library services, is entered into a separate database. This information is used to automatically update the Library's inventory, and to generate reports on the use of Library services.

A workstation has been installed in the Library, allowing the public to perform on-line searches of the Library catalogue as well as of other departmental databases, such as the drillholes database, and databases relating to the Registry of Mineral and Petroleum Rights. In time, access to other databases within the department, such as the metallic mineral occurrences database and the Nova Scotia component of GEOSCAN, will be added to this system. The Library can also access the Novanet catalogue, for listings of materials held by the local universities.

1 Funded by Nova Scotia Department of Natural Resources under the Canada - Nova Scotia Cooperation Agreement on Mineral Development 1990-1992

METALLIC MINERAL OCCURRENCES DATABASE ACTIVITIES[1]

G. DeMont

A program for field checking and sampling metallic mineral occurrences was initiated in April 1990 under the Canada - Nova Scotia Cooperation Agreement on Mineral Development. The objective of the program is to obtain reliable field data required for update and revision of the metallic mineral occurrence data cards and the metallic minerals database. Field checking will provide accurate occurrence locations, descriptions, and samples for geochemical and petrographic analyses. Field checking of selected metallic mineral occurrences on Cape Breton Island was undertaken on N.T.S. map sheets 11F/15, 11F/16, 11K/02, 11K/03, 11K/07, 11K/10, 11K/15 and 11K/16.

The program of field checking and sample collection of mineral occurrences in Cape Breton Island began in July 1990 and continued during the 1991 field season. Forty-six documented metallic mineral occurrences were checked between 1 June and 1 September 1991. Three industrial mineral occurrences (barite) were also examined in the Lake Ainslie area. Four sites of reported, but not catalogued, mineralization were also examined to determine if they should be given occurrence status. Two of the four will be added to the database. Twelve of the forty-six documented occurrences could not be located in the field. The geology of these sites matched that described in the literature; however, no mineralization was visible in the rocks at the indicated locations.

The confirmed occurrences have been sampled, chained-in to fixed reference points, and in most cases photographed. Host rock and mineralized samples were taken where available. Samples taken will be sent for chemical analyses and the results will be incorporated in the metallic minerals database. Hand specimens will be available for viewing at the NSDME libraries in Halifax and Stellarton. A photographic catalogue of the occurrences will be available at the NSDME library in Halifax. Updated occurrence cards for occurrences field checked in 1991 will be available in early 1992.

The metallic mineral occurrences database contained revised and updated information on 320 occurrences as of 1 September 1991.

1 Funded by Nova Scotia Department of Natural Resources under the Canada - Nova Scotia Cooperation Agreement on Mineral Development 1990-1992

INTEGRATED LAND-USE PLANNING PROJECT[1]

D. B. Hopper

The principal aim of the Integrated Land-Use Project is to develop a land-use planning approach toward promoting greater awareness of the mineral and energy resources in Nova Scotia. A subsequent aim is to provide an opportunity to systematically monitor changing land use and new development in land-use policy.

A main issue lies in the recognition that Nova Scotia, like many other provinces in Canada, is experiencing a greater demand for multiple land-use planning, more specific resource management objectives, and more wilderness protection. Exploration companies share the concern that future access to mineral and energy resource lands will be lost, and thus lower the potential for finding new mines.

The Integrated Land-Use Project recognizes the need to incorporate the concept of sustainable development, which strives to balance the goals of environmental protection and economic development. The project's strategy is based on a proactive approach toward increasing realization among land and resource planners of the mineral and energy potential in Nova Scotia. The project is providing a direct application of the department's inventories of mineral occurrences, drillholes, sand and gravel, and various other layers of geoscientific and land-use data. These data are being compiled to encourage planners, resource managers and the general public to entrench the subject of mineral exploration potential in the decision-making process for planning the use of Nova Scotia's resource lands.

The first phase of the project is in progress, involving the creation of a mineral land-use information base (MINLU), as well as producing a series of county-based Mineral Resource Land-Use (MRLU) theme maps with companion handbooks. Phase II will provide a set of thematic maps covering the province showing potential for mineral, energy and construction material resources. Phase III concerns the development of a provincial land-use policy for mineral and energy lands.

Currently there are several (MRLU) map sets available as open file maps at 1:50 000 scale covering individual counties. These include Halifax County (OFM 88-001 to 88-012), Hants County (OFM 88-017 to 88-022), Cape Breton County (OFM 88-033 to 88-038), Kings County (OFM 88-044 to 88-049), and Lunenburg County (OFM 89-004 to 89-009). Draft map sets completed so far include: Pictou County, Cumberland County, Colchester County, Annapolis County and Digby County.

The project supports the resource protection aims of the province and strives to contribute to improved decision-making for environmental planning. Mineral and energy resource data are key elements to any integrated resource management analysis with aims of deriving a positive strategy for sustainable development. The information produced by the Integrated Land-Use Project will contribute to all integrated land-planning strategies in Nova Scotia, and to the common end of working toward a managed land base that sustains a healthy environment while yielding the necessary resources to support growth.

1 Funded by Nova Scotia Department of Natural Resources under the Canada - Nova Scotia Cooperation Agreement on Mineral Development 1990-1992

DRILL CORE LIBRARIES[1]

J. D. Langille

The Nova Scotia Department of Natural Resources maintains diamond-drill core library facilities at four locations in the province. Two facilities in Stellarton, Pictou County, are located at the department's Regional Office building on Bridge Avenue and on Acheron Court in the Stellarton Industrial Park. The other two facilities are located in the Debert Air Industrial Park, Colchester County, and near Malagawatch, Inverness County. Most activity is centered at the main facility in the Stellarton Industrial Park. The Bridge Avenue location contains mainly coal inventory core and most of the department's earliest acquired core. The Malagawatch building holds Cape Breton salt/potash core and the Debert location is gradually becoming a sample storage site as core is transferred to Stellarton for easier and faster access.

All staff is permanently stationed in Stellarton and only the Stellarton facilities are staffed on a regular, full-time basis. All core in the Stellarton Industrial Park is stored on wooden pallets and is moved with a propane-powered forklift. Some prior notice of an intent to visit is appreciated to accommodate all users in an efficient manner. Visits to Debert and Malagawatch may take longer to arrange but usually can be handled within 48 hours. For further information on the core library activities or requests to visit, please telephone Jim Langille, Core Library Supervisor (902) 752-4842, or John McMullin, Regional Geologist (902) 752-8429, FAX (902) 755-3158, Nova Scotia Department of Natural Resources, Stellarton.

EVALUATION AND REDUCTION PROGRAM

W. J. Palmer

With the exception of a parcel of Esso Resources core from Springhill, no large diamond-drill projects were evaluated. Emphasis was placed on completion of reports and compilation of 'retain and discard' core lists for all major projects. To date, 63 528 m of core were examined, of which 35 206 m were suggested for retention and 28 322 m for disposal. An integral part of the evaluation program was to photograph all core suggested for disposal. However, this effort has been expanded to include photographing all core being evaluated. Getty Meaghers Grant and Esso Springhill core have been photographed on 35 mm slides. These slides will be available for viewing at the Stellarton Industrial Park facility.

COMPUTER PROGRAM

D. F. Weir

During the year a revised list of the core stored in the Stellarton Industrial Park was completed. This list was entered into a Revelation® database and is used in searching for and producing specific lists of core that may be requested. There are approximately 1000 records in the database, with information on as many as 20 holes per record. This information includes the company name, drilling location, the year that the hole was drilled, where the holes are stored at the Core Library, the hole number, interval, box numbers and notes of interest on that hole.

Core Evaluation Reports on Gays River and Meaghers Grant (Getty Mines), Walton Mine (Magnet Cove Barium Corp. and Dresser Industries), Loch Lomond (Kaiser Celestite) and Silver Mine (Phelps Dodge and Yava Mines) have been added to the database in separate files. These reports can also be searched and listed by any of the fields in the report.

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1 Funded by Nova Scotia Department of Natural Resources under the Canada - Nova Scotia Cooperation Agreement on Mineral Development 1990-1992

MINERAL INVENTORY

N. A. Lyttle

'GEOSCAN' BIBLIOGRAPHIC DATABASE ACTIVITIES

(J. M. Vavra, N. A. Lyttle, S. Saunders)

Indexing and on-line data entry into GEOSCAN continued for Nova Scotia Department of Mines and Energy (NSDME) bibliographic records. GEOSCAN is a bibliographic database which provides access to publicly available geoscience literature concerning the Canadian landmass and offshore regions. The database presently contains over 126,500 records, and is cooperatively produced from the indexing contributions of 14 federal, provincial and professional geoscience organizations located throughout Canada. The Geological Survey of Canada, through the National GEOSCAN Centre, coordinates these indexing activities and provides computer resources in support of this project.

During the period 1 August 1990 to 31 July 1991, 384 new NSDME records were added to GEOSCAN. These records consisted of 103 assessment reports, 36 open file maps, 40 open file reports, 38 open file illustrations, 130 publications, 33 theses, 3 journal literature references and 1 internal document, representing a 3.4% increase in the Nova Scotia component of the database. As of 31 July 1991, the database contained 11,731 NSDME records consisting of 5240 assessment reports, 2379 publications, 1283 journal literature references, 1063 open file maps, 945 open file reports, 55 open file illustrations, 756 theses, 7 internal documents and 3 books.

Three 10-year bibliographic indexes to NSDME records were released in the fall of 1991. These indexes are: Report 91-2 *NTS Location Index to Nova Scotia Department of Mines and Energy Assessment Reports, Open Files, Publications and Theses 1981-1990*; Report 91-3 *Author Index to Nova Scotia Department of Mines and Energy Assessment Reports, Open Files, Publications and Theses 1981-1990*; and Report 91-4 *Subject Index to Nova Scotia Department of Mines and Energy Assessment Reports, Open Files, Publications and Theses 1981-1990* (Report 91-4 available on microfiche only).

GEOCHEMICAL MAPS DATABASE

(P. L. LeBlanc, N. A. Lyttle)

During the summer of 1991, a project was conducted to identify, index and enter into a database all pertinent information on Nova Scotia Department of Mines and Energy and Geological Survey of Canada published and open filed geochemical survey maps on Nova Scotia. Information from 138 geochemical maps was entered into the database.

The information in the geochemical map database, in the form of a data sheet for each individual map, plus an index map showing the plotted location of each geochemical map in Nova Scotia with respect to the NTS grid, was released as Open File Report 91-011 in the fall of 1991. Updated versions of Open File Reports 90-011 (NSDME Geology maps), 90-012 (GSC Geology maps), 90-014 (NSDME and GSC Surficial Geology maps) and 90-016 (GSC Colour Aeromagnetic maps) were also released in the fall as Open File Reports 91-007, 91-008, 91-009 and 91-010.

VARIOUS COMMODITIES PROJECT[1]

R. MacDonald

The Various Commodities Project was initiated to help further identify, increase the database on, and promote the development of several industrial mineral deposits within the province. Detailed studies have been conducted and reports released on several deposits, including the Glencoe limestone deposit, the Chegoggin Point silica deposit and the Shubenacadie River heavy mineral sands. A number of smaller, lesser known industrial mineral deposits have been investigated and promoted to industry.

The project geologist has served as a promoter and resource information person to established companies within the province seeking additional reserves, companies exploring Nova Scotia's industrial mineral potential, and other government agencies promoting our province's resources.

SUMMARY OF INVESTIGATIONS

Limestone and dolomite deposit investigation and promotion represent a large portion of the Various Commodities Project. Nova Scotia has many large, high quality, speciality grade deposits of carbonates which have high potential for development and high value in today's environmentally conscious world. The best of these deposits have been investigated and promoted as part of this project.

Nova Scotia also has high quality deposits of andalusite, barite, garnet, peat and silica, which have been explored and promoted for exploration and development. The exceptional high quality of several of these Nova Scotian deposits, combined with the potential to transport large tonnages economically in large ocean-going vessels, places this province on the doorstep of markets continually developing worldwide.

The Nova Scotia Department of Natural Resources database has been continually upgraded and revised for the commodities included in the project's mandate. Future work will be directed to investigating commodities in high demand and also provincial deposits of industrial minerals which have excellent potential but at present have a depressed market. A proposed exploratory drillhole in a previously unexplored andalusite deposit is planned for the immediate future. This indicates the type of response the project is attempting to achieve as andalusite is presently one of the most sought-after commodities in the market place.

PUBLICATIONS

A report on the 1988 drilling program to further explore the huge limestone and dolomite deposit at Glencoe, Inverness County, was released as Open File Report 90-020. A map to accompany this report was released as Open File Map 90-002. A report on the exploration program and diamond-drilling program on the Chegoggin Point to Lake George, Yarmouth County, silica and garnet deposit was released as Open File Report 90-009. The final report of the Various Commodities Project, highlighting 14 different industrial minerals found in deposits having development potential within the province, is in final preparation. Information Circulars previously released in 1988 outlining *Limestone and Dolomite in Nova Scotia* and *Silica in Nova Scotia* are being updated and revised, and will be released shortly.

1 Funded by Nova Scotia Department of Natural Resources under the Canada - Nova Scotia Cooperation Agreement on Mineral Development 1990-1992

MINERAL EXPLORATION MONITORING

P. D. McCulloch

Mineral exploration and development in Nova Scotia during the first nine months of 1991 demonstrated a moderate drop in the level of activity from the previous year, with expenditures for 1991 estimated at $4-6 million compared to $10 million in 1990. A total of 8,451 general claims were staked during the first half of 1991, down slightly from the 8,727 claims staked during the same period in 1990.

Exploration for lead and zinc highlighted mineral exploration in the province during the year, reflecting a renewed interest in base metals. Market prices for the traditional metals have strengthened significantly between mid 1987 and early 1989, and this, combined with a downturn in the price of gold, has resulted in a shift in focus from gold to base metals. Programs were undertaken by several companies in the Lower Carboniferous Windsor Group carbonates through northern mainland Nova Scotia and western Cape Breton Island. Highlights of this work included the continuation of a detailed examination of the Windsor Group carbonates by Westminer Canada Limited in the Shubenacadie and Musquodoboit basins of central Nova Scotia. Falconbridge Limited also continued a detailed evaluation of the Jubilee Pb/Zn deposit at Little Narrows, Victoria County, and Scotia Prime Resources Incorporated continued work on several properties in Pictou County and western Cape Breton Island. Work was also continued by Falconbridge Limited in the Hadrynian volcanics and metasediments of the Fourchu Group in southeastern Cape Breton Island

The level of activity for gold was down significantly from 1990 continuing a trend that began in mid 1988. Work was focused primarily on the evaluation of former gold-producing properties hosted by the Cambro-Ordovician metasedimentary rocks of the Meguma Group in central mainland Nova Scotia. Additional work was continued on the Upper Seal Harbour gold property in Guysborough County by Minnova Incorporated, in a joint venture agreement with Exploration Orex Incorporated. Antioch Resources (N.S.) Limited also completed additional work on the Caribou gold property in Halifax County. Limited work was carried out in the Cambrian and Hadrynian rocks of the Cape Breton Highlands by Noranda Exploration Company Limited and Seabright Explorations Incorporated.

Exploration for industrial minerals, including limestone, gypsum and several other commodities, has continued at roughly the same level of activity as in recent years. Work was undertaken primarily by local producers to either expand on current reserves or to evaluate new deposits for future development.

AGGREGATE DRILLING PROJECT[1]

G. Prime

The northern half of Cumberland County has been identified as an area for concern in terms of aggregate potential. Previous studies under the aggregate program have determined that there is an absence of granular aggregate in parts of the region. Other areas have an abundance of sand and gravel; however, the quality is poor. This is largely due to a clast composition of sedimentary rocks that exhibit poor mechanical strength, low resistance to weathering and an abundance of fines. The result is that this region, which contains the major aggregate market in the County, must make due with the low grade materials found locally or face expensive haulage charges to obtain better aggregate from distant sources.

The alternative to sand and gravel is crushed stone aggregate. In northern Cumberland County the crushed stone or bedrock potential resides primarily in the igneous-metamorphic rocks associated with the Cobequid Highlands. In 1990 a drilling program was prepared to evaluate these rocks, located near the Amherst-Springhill market. The priorities in selecting the drill sites were (1) the apparent suitability of the rock types as aggregate and (2) their proximity to the market. Based on these criteria, the northwest side of the Cobequid Highlands between Lakelands and Williamsdale, Cumberland County, was chosen. Due to the vastness of the area, no attempt was made to define or drill specific deposits. Rather, the objective was to examine a range of rock types and provide a general assessment of their potential.

The drilling project, which commenced in late June 1991, consists of a series of shallow holes ranging from 15-75 m deep and located within a few kilometres of the north edge of the Cobequid Highlands. Drilling should be completed by December 1991. A report will be prepared at the conclusion of the study providing analytical information and evaluating the aggregate potential of the bedrock in the area.

1 Funded by Nova Scotia Department of Natural Resources under the Canada - Nova Scotia Cooperation Agreement on Mineral Development 1990-1992

CARBONIFEROUS MINERAL OCCURRENCE PROJECT[1]

R. J. Ryan and P. McGinn

The mineral and energy resources contained within the Carboniferous to Permian sedimentary basins in Nova Scotia represent approximately 70% of the mineral production in the province. These occurrences have been the subject of continuing research by the department for the last several years. It is our hope that by documenting the occurrences and evaluating the metallogenic environments we can stimulate additional exploration and possible exploitation of the minerals.

By the end of 1991 we hope to produce an open file report documenting the occurrences within the Cumberland Basin and the Stellarton Graben areas of northern Nova Scotia. These areas include part or all of N.T.S. sheets 11E/10, 11, 12, 13 and 14, and 21H/9 and 10. This report will include geology, assay reports, petrography, isotope geology and exploration models for the various occurrences in the area.

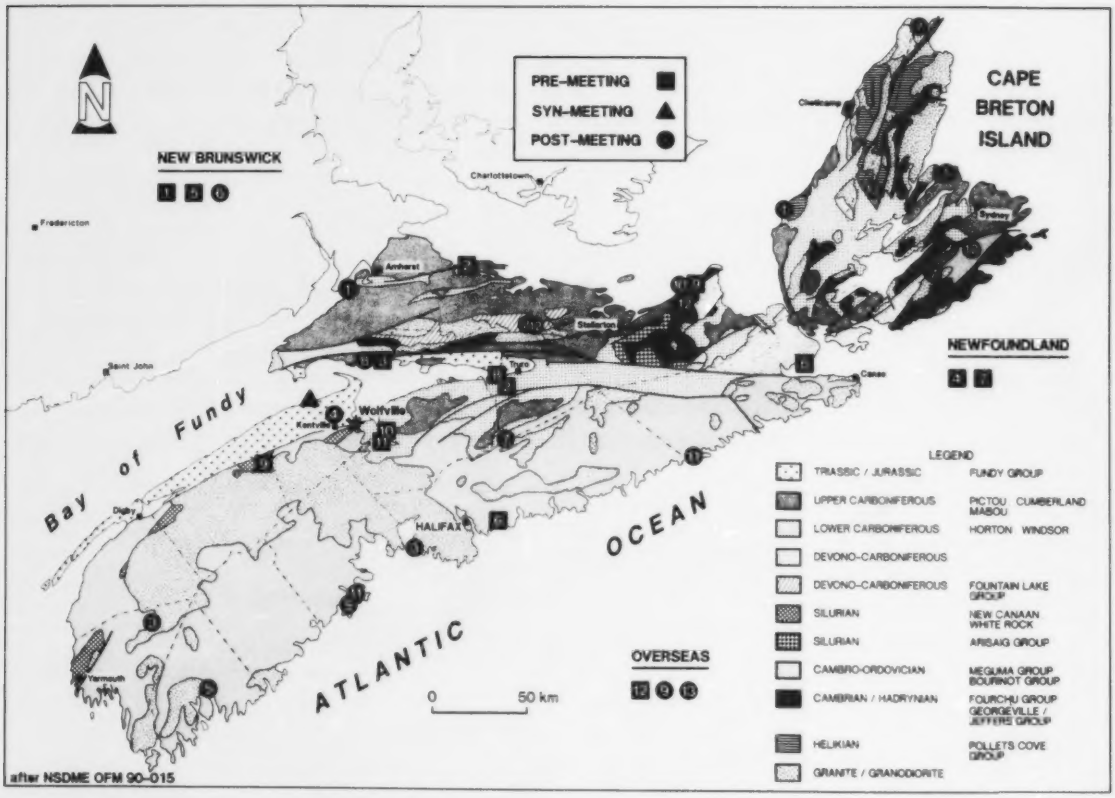
During the 1991 field season mineral occurrences in the Guysborough area (11F/05) were examined. Many Fe, Cu and Au occurrences were field checked and sampled. An open file report for the 11F/05 area will be released before the end of March 1992.

1 Funded by Nova Scotia Department of Natural Resources under the Canada - Nova Scotia Cooperation Agreement on Mineral Development 1990-1992

GAC/MAC WOLFVILLE '92: ANNUAL MEETING AND FIELD TRIPS

R. C. Boehner, Field Trip Coordinator

The GAC/MAC WOLFVILLE '92 Joint Annual Meeting will be hosted in Wolfville, Nova Scotia, on the 25-27 May 1992. The location is unique: it is not the traditional major urban center and it is very accessible to an impressive variety of Appalachian geological environments in Atlantic Canada. The 26 field trips linked to the symposia, special and general sessions are an integral feature of the meeting which will attract a diverse group of geoscientists from across Canada, the United States and Europe.



PRE-MEETING FIELD TRIPS

A1 A Geotraverse across the Avalon-St.Croix terrane boundary, N. B.
A2 Economic geology of industrial minerals, Windsor Group in N. S. and N. B.
A3 Fundy Basin rift tectonics and sedimentation.
A4 Gold mineralization in western Newfoundland.
A5 Granite-related mineral deposits, Mount Pleasant-Saint George Batholith
A6 Younger Dryas glaciers and Holocene coastal sedimentation in Nova Scotia.
A7 Lithoprobe east in Newfoundland: the Burgeo Road transect.
A8 Tidal sedimentation in the Minas Basin-Cobequid Bay area.
A9 Oolitic ironstones of the northern Appalachians
A10 The bio- and lithofacies of the Horton and Windsor gps. in their type area.
A11 Visit to Sheffield Mills Vineyard and Saint Famille Wineries.
A12 Volcanic stratigraphy of the Greek Islands.

SYN-MEETING FIELD TRIPS

B1 The spectacular North Mountain Basalts.

POST-MEETING FIELD TRIPS

C1 Carboniferous coal basins of Nova Scotia.
C2 Cobequid Highlands, Nova Scotia: magmatism, volcanism and strain.
C3 Granite- and metasediment-hosted mineral deposits of southwest N. S.
C4 Hydrogeological and groundwater interests in the Annapolis Valley.
C5 Low pressure regional metamorphism in the Meguma Terrane.
C6 Massive sulphide deposits and geology in northern New Brunswick.
C7 Mineral deposits of Nova Scotia.
C8 Parrsboro panorama: Bakers bread to dinosaurs bones.
C9 Scandinavian economic mineral deposits.
C10 Sedimentology and palaeontology of the Siluro-Devonian Arisaig Gp.
C11 Strain history of the Meguma Group, Lunenburg and Ecum Secum.
C12 The Avalon Composite Terrane of Maritime Canada.
C13 The sedimentology and tectonics of the Lusitanian Basin of Portugal.

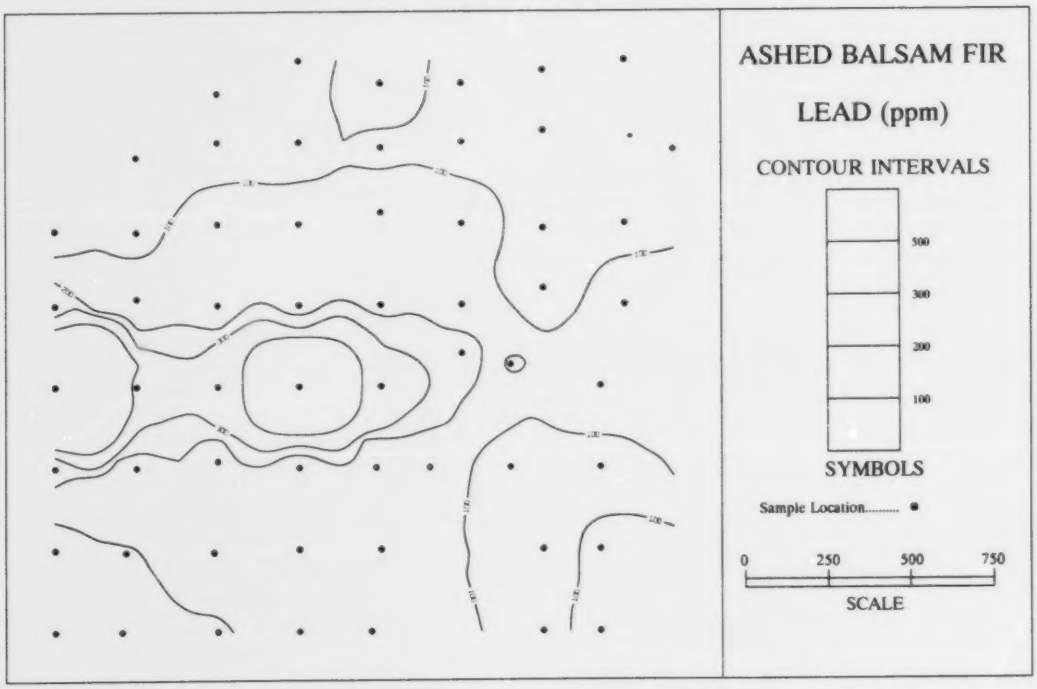
APPLICATIONS OF COMPUTER SOFTWARE FOR PRESENTATION OF GEOCHEMICAL DATA[1]

F. J. Boner

Although the collection, preparation and analysis of a geochemical sample follow strict guidelines, the manipulation and presentation of the resulting data do not. One method of presenting geochemical data, using computer software that requires only moderate computer skills, is described below.

Rockware•, a popular software program dedicated to the earth sciences, has been used extensively by the Mineral Resources Division in the evaluation and presentation of geochemical and geological data. Recent detailed multi-media geochemical surveys provide ideal data for the Rockware• program. Spatial data are best presented through contoured plots or proportional plots. Contouring draws attention to high and low trends in the dataset whereas proportional plots highlight individual sample highs and lows. Contoured till clast percentages are used to delineate lithological changes in clast geology, and subsequently to define the relationship between till and underlying bedrock.

A typical procedure for data presentation would include the following steps. Geochemical analyses are received on diskette in ASCII format. Initial editing, consisting of removing standards and sample splits to check for analytical precision and accuracy, is done with Lotus 1-2-3•. An ASCII file is saved for statistical analysis using Systat• and Lotus 1-2-3•. Grid locations are appended and the combined data table is printed on a laser printer using Lotus Allways•. A second ASCII file is made and edited for use in the Rockware• program and for graphic display. An example of a Rockware• contoured plot of Pb in Balsam fir twigs and branches at the Yava Pb deposit is shown below.



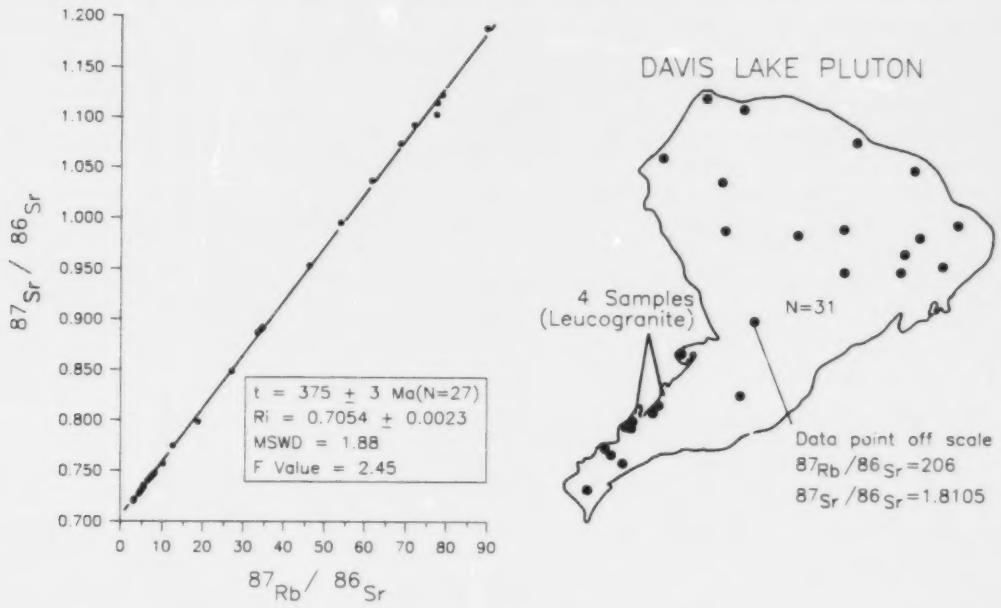
1 Funded by Nova Scotia Department of Natural Resources under the Canada - Nova Scotia Cooperation Agreement on Mineral Development 1990-1992

AN Rb/Sr GEOCHRONOLOGICAL STUDY OF THE DAVIS LAKE PLUTON, SOUTH MOUNTAIN BATHOLITH, SOUTHERN NOVA SCOTIA: EVIDENCE FOR A 375 Ma TIME OF EMPLACEMENT[1]

A. K. Chatterjee and R. F. Cormier[2]

The Davis Lake pluton (DLP; 850 km^2) forms the westernmost extention of the large, peraluminous, Devono-Carboniferous South Mountain Batholith. The DLP is composed predominantly of coarse- to fine-grained, biotite-muscovite leucomonzogranite with lesser amounts of granodiorite and leucogranite, and is chemically zoned with indices of fractionation (e.g. K/Rb, DI) and specialization (e.g. Rb, F, Li, Sn) increasing southwestward toward the leucogranite phases. Of particular significance is the presence of Sn and base metal mineralization in the western part of the DLP, including the large East Kemptville deposit (initial reserves 56 million tonnes, 0.165% Sn) operated by Rio Kemptville Tin Corporation (annual production ca. 4000 tonnes tin).

Previous geochronological studies of the DLP, including Rb-Sr whole-rock and $^{40}Ar/^{39}Ar$ dating of micas, indicated variable ages of 370-300 Ma for the intrusive rocks. In order to resolve this apparent conflict in ages for the DLP a detailed study of the entire pluton was initiated in order to evaluate the potential for: (1) different intrusive pulses and/or (2) the possibility of variable resetting of the isotopic systems. In the present study 31 whole-rock samples were analyzed representing all phases of the DLP and equal geographic dispersal. On a standard $^{87}Sr/^{86}Sr$ *versus* $^{87}Rb/^{86}Sr$ isochron plot the data are seen to define a single regression line corrresponding to an age of 375 ± 3 Ma with an MSWD value = 1.88 and initial $^{87}Sr/^{86}Sr$ ratio = 0.7054 ± 0.0023; the four leucogranites scatter about a 375 Ma reference line. The data suggest that all samples share a common source and are temporal equivalents. In addition, the results indicate that the DLP is a temporal equivalent of the 370 million year old South Mountain Batholith.



1 Funded by Nova Scotia Department of Natural Resources under the Canada - Nova Scotia Cooperation Agreement on Mineral Development 1990-1992

2 Department of Geology, St. Francis Xavier University, Antigonish, Nova Scotia B2G 1CO

INVESTIGATIONS INTO GOLD MINERALIZATION IN THE GOLDBORO AREA[1]

M. C. Corey and R. F. Mills

The Goldboro project has focused on gold mineralization along the Upper Seal Harbour anticline in the Goldboro area. Study areas included the Boston-Richardson, East and West Gold Brook Mines and the Dolliver Mountain Mine. The most profitable of these was the Boston-Richardson Mine which produced 53,835 oz. of gold at an average grade of 0.136 oz./ton. Gold production ceased in 1912.

The Upper Seal Harbour anticline trends east with a variable eastward plunge at 10-35°. The axial surface dips to the south at <5° from vertical. Strata on the limbs of the anticline dip steeply from 65-75° north and south.

Mineralization is hosted by en echelon and less common bedding parallel quartz veins situated along the anticline fold hinge. The en echelon veins are stratabound but irregular and are hosted by massive to interbedded grey to black pelite and semi-pelite. The occurrence of black pelite appears to be restricted to the immediate fold hinge area. The amount of veining within these beds is highly variable. Gold occurs as millimetre-sized grains in massive milky quartz to micron-sized inclusions within vein- and wall rock-hosted sulphides. These beds reflect upper greenschist to lower amphibolite facies metamorphism and range in thickness from <10 cm to approximately 2 m.

Several aspects of the mineralization will be investigated as part of the current study. This work includes establishing the mineralogy and mineral chemistry of both veins and host rocks, the types and styles of alteration and their geochemical signatures, and documenting the various structural features present. In addition, approximately 200 m of exposed strata on the north limb adjacent to the fold axis were mapped in detail across a section <500 m northwest of the Dolliver Mountain deposit. This section contains several zones of semi-pelite hosted, en echelon quartz veins similar to those described from the deposits along the fold hinge. Four periods of deformation have been recognized from mapping. Also present near the fold hinge are a series of kink bands which trend southwest (145°) and plunge at 40°. It is interesting to note that the orientation of these kink bands is similar to that of high-grade ore shoots indentified within the Boston-Richarson Mine.

A detailed till survey was carried out to complement the bedrock mapping. Samples were collected for analysis in an effort to determine the nature of gold and other heavy minerals within surficial materia derived from this type of gold deposit.

1 Funded by Nova Scotia Department of Natural Resources under the Canada - Nova Scotia Cooperation Agreement on Mineral Development 1990-1992

EDUCATION AND PUBLIC AWARENESS[1]

H. V. Donohoe, Jr.

Developing the public's understanding and appreciation for the mineral resources, geology and mineral industry of Nova Scotia is the essential part of the Education and Public Awareness Program. Our clients include people in government agencies, schools (students and teachers), and exploration and mining companies as well as residents and visitors. Developing a communications strategy of printed material, displays, audio-visual material, workshops and talks for these clients is challenging. Most of the activities of the Education and Public Awareness Group were financially supported by the Public Information Program of the Canada-Nova Scotia Cooperation Agreement on Mineral Development.

During 1991, the Education and Public Awareness Group provided a wide range of services that reached more than 125,000 people. During the year, one field trip, five school lectures, ten interpretive walking tours, four displays, and five seminars were prepared and presented. Three of the displays were jointly planned and operated with the Corporate Communications Sector of Energy, Mines and Resources Canada. The principal theme of all these activities was the mineral industry: its importance and relevance to Nova Scotia and Canada. Describing and interpreting the geology and mineral resources of the province and the activities of the Department of Natural Resources are the other essential parts of the theme presentation.

Other activities involved the completion of *The Mining Kit* for distribution to science teachers in Nova Scotia schools through the Nova Scotia Museum, and preparation of *The Teachers Guide to the Appalachian Story* for one of the Atlantic Geoscience Society's videos. Another activity of the Group was representing the department on an implementation committee for the development of a gold discovery centre on the Eastern Shore. Planning, organizing and coordinating the 48th Mines Ministers' Conference hosted by the department in September 1991 was another major project of the Education and Public Awareness Group.

During the amalgamation of the departments of Lands and Forests and Mines and Energy into the new Department of Natural Resources, the Education and Public Awareness Group was transferred to the Extension Services Division. This division now has broad responsibilities for developing public programs that provide information to client groups for most of the department's areas of responsibility.

The work of the Education and Public Awareness Group in the department increases the knowledge of Nova Scotia's mineral resources, geology and mineral industry. This work allows a broader understanding of the importance and influence of minerals and mining in everyday life and future planning. The Education and Public Awareness Group works closely with many groups, government agencies and individuals to foster this understanding and appreciation.

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1 Funded by Nova Scotia Department of Natural Resources under the Canada - Nova Scotia Cooperation Agreement on Mineral Development 1990-1992

DEBRIS AVALANCHES IN THE SOUTHERN CAPE BRETON HIGHLANDS[1]

P. W. Finck

Debris avalanches influence present and future land-use in the Cape Breton Highlands. Mine development, exploration and exploration methods, forestry practices and the sport fishery could all be affected by debris avalanches.

Data are being collected to determine the distribution, frequency and factors controlling the occurrence of the avalanches, for example: (1) bedrock lithology and structure, (2) slope angle, (3) slope material, (4) earthquakes, (5) vegetation type (hardwood vs. softwood; living vs. dead), (6) logging operations, (7) natural causes such as budworm defoliation, (8) precipitation, (9) hydrogeology and (10) morphology of the brooks.

During the 1991 field season over 55 debris avalanches were examined in the area south of Cape Breton Highlands National Park. Age of the debris avalanches was determined using tree-ring dating methods (dendrochronology) to demonstrate whether the avalanches are a steady-state geological phenomenon, an unusual (catastrophic) event, a result of recent anthropogenic factors, or an ecological phenomenon. Examination of scars on trees resulting from damage by airborn rock debris along the edges of the avalanches date the year and possibly even the season of the avalanche event.

Preliminary results indicate an increase in avalanche frequency from 1980 until present. The avalanches occur on steep slopes (>35) cut in crystalline bedrock containing more than one steeply-dipping joint set. Debris consists of (1) cobble to boulder sized material with minor fines, or (2) colluviated, weathered bedrock, or (3) stony till with a sandy matrix. Vegetation consists of varying amounts of hardwood, living softwood and dead softwood. Avalanches are concentrated in the upper reaches of the Northeast Margaree Valley, Middle Branch North River, Barachois River and West Branch Indian Brook, where there is increased concentration of dead softwood trees, apparently killed by budworm. Stream undercutting does not appear to be a factor in destabilizing the already oversteepened slopes. Possible triggering mechanisms such as earthquakes, logging or unusual amounts of precipitation have not yet been examined.

Some of the questions that may be ultimately answered are: (1) Might mine development affect slope stability and result in debris avalanche? (2) Do debris avalanches and resulting sediment input into the brooks affect stream sediments and exploration techniques? (3) Is there any relation between logging or budworm defoliation and the occurrence of debris avalanches? (4) Do debris avalanches affect the ecology of salmon brooks by catastrophically loading large volumes of coarse sediment into streams?

1 Funded by Nova Scotia Department of Natural Resources under the Canada - Nova Scotia Cooperation Agreement on Mineral Development 1990-1992

U-PB AND $^{40}AR/^{39}AR$ MINERAL AGES FROM CAPE NORTH, NORTHERN CAPE BRETON ISLAND: IMPLICATIONS FOR ACCRETION OF THE AVALON COMPOSITE TERRANE[1,2]

J. D. Keppie, R. D. Dallmeyer[3] and T. E. Krogh[4]

Isotopic studies have been used to determine protolith and tectonothermal ages in rocks of the Cape North and Money Point groups and two plutons, which form part of the Avalon Composite Terrane. Colourless, euhedral zircon crystals from low grade metarhyolite in the Money Point Group record a concordant U-Pb age of 427.5 ± 4 Ma which is interpreted to date the time of extrusion. This provides a maximum age of Middle Silurian for polyphase deformation and concomitant greenschist-amphibolite facies metamorphism that affected the Cape North area in the eastern half of a major, sinistral, positive flower structure. Monazite from the Cape North granite, intruded during peak metamorphic conditions, yielded nearly concordant data with a $^{207}Pb/^{235}U$ age of 414 ± 3 Ma. This dates the time of crystallization of the Cape North granite. Metamorphic hornblende from the Cape North and Money Point groups records variably discordant $^{40}Ar/^{39}Ar$ age spectra which define plateau and/or isotope correlation ages of ca. 380-390 Ma. Muscovite from these units displays generally concordant spectra which define plateau ages ranging between ca. 365 and 375 Ma. Muscovite samples from the syntectonic Cape North granite and the post-tectonic Relay Station granite record plateau ages of ca. 380-382 Ma. The $^{40}Ar/^{39}Ar$ ages suggest that relatively rapid post-metamorphic cooling occurred during the Devonian. These isotopic results and petrological data indicate that burial of the Cape North units to ca. 18 km, metamorphism, uplift and erosion occurred in ca. 60 million years. Such rates are comparable to those recorded in modern transpressive tectonic regimes. The calc-alkaline nature of the Money Point volcanic rocks suggests derivation above a subduction zone. A correlative Silurian-Devonian tectonothermal event recorded in southern Newfoundland probably records the accretion of the Avalon Composite Terrane with the Dunnage Zone.

1 Funded by Nova Scotia Department of Mines and Energy under the Canada - Nova Scotia Mineral Development Agreement 1984-1989
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CAPE BRETON HIGHLANDS MAPPING PROJECT[1]

L. J. Ham and R. J. Horne

Bedrock mapping (1:10 000 scale) in the south-central Cape Breton Highlands (portions of NTS map sheets 11K/7 and 11K/10) was initiated in the summer of 1990 and continued in 1991. A preliminary compilation of this work is provided on the opposite page and a table, below, describes the various units and their contact relationships.

Unit	Lithology	Contact Relationships
DEVONIAN-CARBONIFEROUS		
Peters Brook pluton	medium grained, equigranular monzogranite; locally intensely sheared	fault contact with gneissic complex; intrusive (dykes) and shear contact with Taylors Barren pluton
Margaree pluton	medium- to coarse-grained, megacrystic bi (hb?) monzogranite to syenogranite	fault contact with Taylors Barren pluton; intrusive contact (dyke) with gneissic complex
West Branch North River pluton	medium- to coarse-grained, bi-hb granodiorite and medium- to coarse-grained monzogranite	intrusive contact (dyke) with Taylors Barren pluton and undivided felsic to intermediate volcanics and gneissic complex
SILURIAN		
Taylors Barren pluton	variably foliated (augen) monzogranite	intrusive (moderately transposed) and locally fault contact with gneissic complex; fault contact with undivided metasedimentary and metavolcanic rocks - unit a
PRECAMBRIAN-SILURIAN*		
undivided felsic to intermediate volcanics	predominantly fine- to medium-grained felsic and intermediate pyroclastics and flows(?) with minor black slate	fault contact with West Branch North River pluton
gneissic complex	mainly strongly foliated qtz-fspar-bi orthogneiss with lesser paragneiss; including amphibolite and pelitic bi-gr-ky gneiss	inferred transposed contact with undivided metasedimentary and metavolcanic rocks - unit a - and metasedimentary rocks - unit b
undivided metasedimentary and metavolcanic rocks - unit a	includes pelitic gr-bi schist, pelitic gr-ky-st schist, amphibolite, quartzite	inferred tranposed contact with diorite complex
metasedimentary rocks - unit b	includes bi-gr-ky-st? schist, qtz-fspar-bi gneiss, amphibolite, quartzite?, minor marble, minor calcsilicate	inferred transposed contact with gneissic complex
diorite complex	fine- to coarse-grained, unfoliated to well-foliated diorite and intermediate to mafic quartzofeldspathic orthogneiss	inferred transposed contact with undivided metasedimentary and metavolcanic rocks - unit a

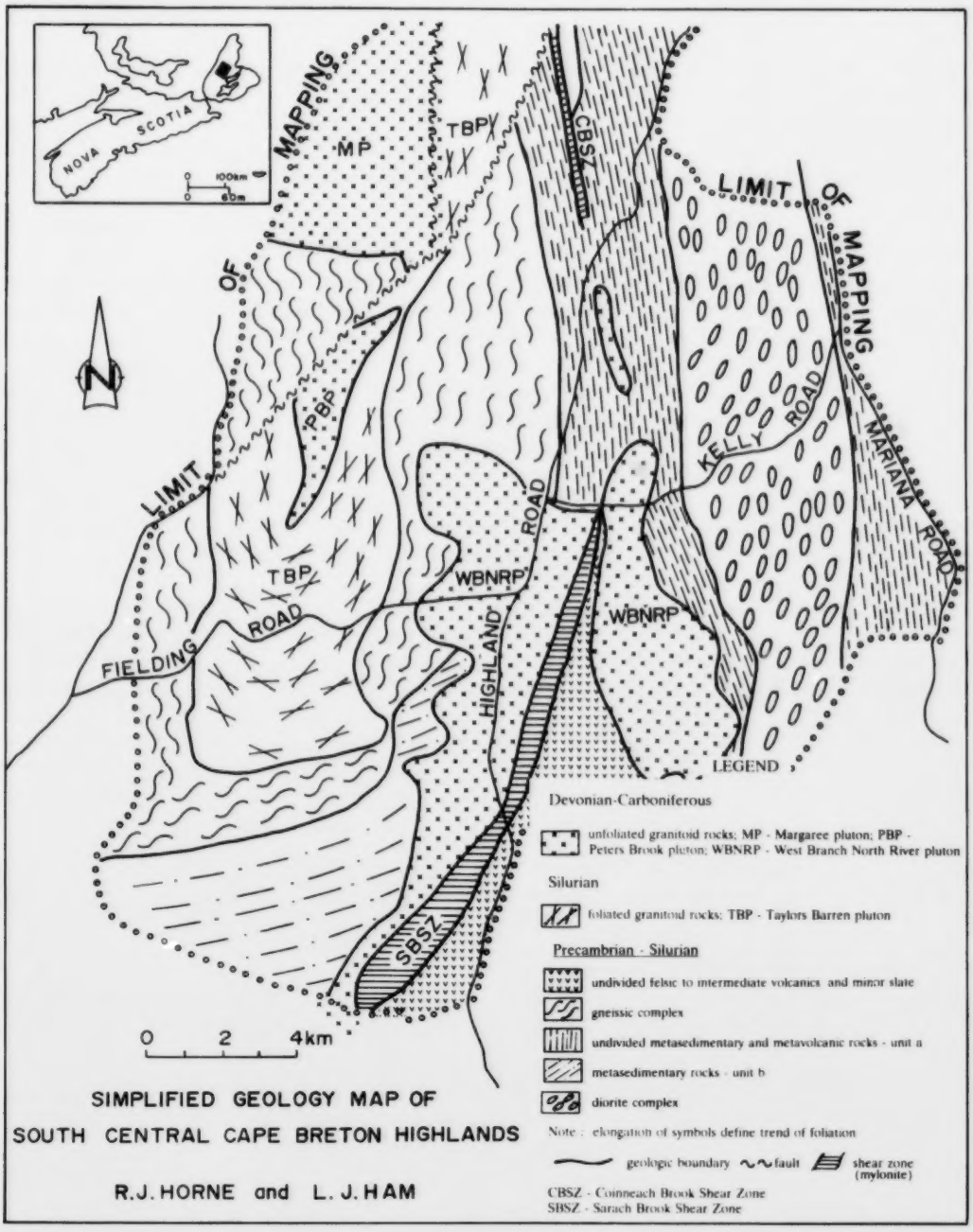
bi = biotite; hb = hornblende; qtz = quartz; fspar = feidspar; gr = garnet; ky = kyanite; st = staurolite

*No age sequence implied

1 Funded by Nova Scotia Department of Natural Resources under the Canada - Nova Scotia Cooperation Agreement on Mineral Developm 1990-1992

COMPILATION OF PRELIMINARY RESULTS FROM THE CAPE BRETON HIGHLANDS MAPPING PROJECT[1]

R. J. Horne and L. J. Ham



1 Funded by Nova Scotia Department of Natural Resources under the Canada - Nova Scotia Cooperation Agreement on Mineral Development 1990-1992

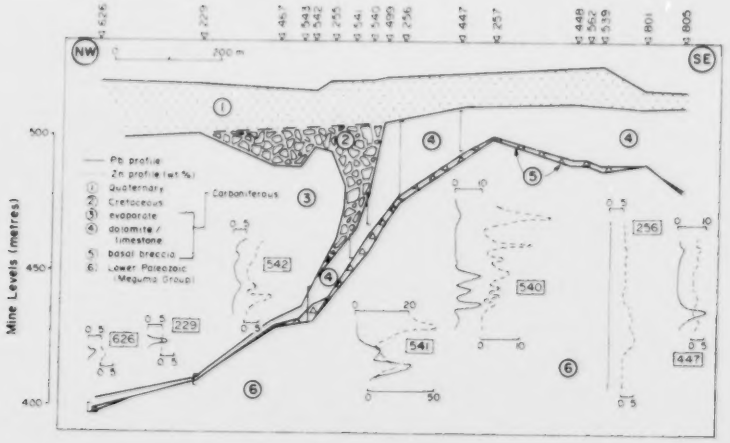
PRELIMINARY RESULTS OF GEOLOGICAL STUDIES AT THE GAYS RIVER DEPOSIT, SOUTHERN NOVA SCOTIA: A CARBONATE-HOSTED PB-ZN DEPOSIT OF PERMO-CARBONIFEROUS AGE[1]

D. J. Kontak

The Gays River Pb-Zn deposit, located in southern Nova Scotia about 55 km NE of Halifax (45°01'55" N, 63°21'30" W), is one of several significant centres of Pb-Zn mineralization hosted by Carboniferous rocks of the Maritimes Basin. The deposit was mined from 1978-1982 by Esso Minerals Ltd. and is currently under assessment by Westminer Canada Ltd., who have outlined preliminary reserves of ca. 2.4 million tons at 6.3% Pb and 8.7% Zn. The deposit has generally been classified as a Mississippi Valley type by previous workers.

The deposit is located in a dolomitized, Lower Carboniferous carbonate reef complex which developed on a topographic high underlain by deformed, lower Paleozoic metaturbidites of the Meguma Group. The structure of the reef complex and, hence, mineralization were probably controlled by paleotopography. A typical cross-section through the central part of the deposit (C Zone) in Figure 1 illustrates the following broad scale geological features: (1) mineralization is generally confined to the dolomitized limestone, (2) ore thickness is strongly controlled by the thickness of the carbonate unit, (3) mineralization is localized to the spur areas of the reef rather than the saddle, and (4) ore grades are highly variable and the Zn/Pb ratio tends to increase up-section. The mineralization consists of disseminated to massive (i.e. >90% metal) Ag-poor galena and Fe-poor sphalerite, and whereas galena is fine- to coarse-grained (<5 mm), ore-grade sphalerite (buff to yellow) is aphanitic. However, low-grade sphalerite infilling vugs is orange and grain size is up to 3 mm. The Pb-Zn ore has formed by replacing the carbonate rocks and the process maintained constant volume; hence, massive galena ore may be extremely vuggy.

Work to date and in progress involves: (1) logging of drill core, (2) petrographic study and lithogeochemistry of both ore and host rock, (3) fluid inclusion studies of ore and gangue, (4) stable isotope analysis of the ores and (5) geometric analyses of the ore body using cross-sections such as that illustrated in Figure 1. This new information, in conjunction with previous work, will be used in assessing controls on deposit formation.



1 Funded by Nova Scotia Department of Natural Resources under the Canada - Nova Scotia Cooperation Agreement on Mineral Development 1990-1992

A LITHOGEOCHEMICAL STUDY OF THE METASEDIMENTARY COUNTRY ROCKS AT THE EAST KEMPTVILLE TIN DEPOSIT, YARMOUTH COUNTY, NOVA SCOTIA[1]

D. J. Kontak and J. Dostal[2]

The East Kemptville Sn (Cu-Zn-Ag) deposit, Yarmouth County, is hosted by a topaz-muscovite leucogranite which intrudes lower Paleozoic metasedimentary rocks of the flyschoid Meguma Group (Goldenville Formation). A lithogeochemical study of the metasedimentary rocks along the northern granite-sediment contact was initiated to investigate several features: (1) to determine if fluid has infiltrated the relatively fresh-looking and highly indurated sedimentary rocks, (2) to determine the presence, extent and geochemical signature of a primary dispersion halo and (3) to determine which, if any, elements could be used as pathfinders for purposes of exploration.

The metasedimentary rocks are mixed psammites and pelites and the limited amount of S_0 data suggests the presence of a northeast-trending anticline. The sediments are fine- to medium-grained, have a variably developed cleavage and more rarely an overprinting shear cleavage, and are hilghly indurated due to the proximity of the granite intrusion. Spotted hornfels textures (<5 mm) are present in pelitic units, but not ubiquitous. Petrographically the rocks contain variable proportions of the primary assemblage qtz-biot-musc-feld-chl-carb-cord(?). Secondary, hydothermally-generated minerals (musc-chl-cassit-sphal-opaques-fluor) occur either as disseminations or narrow selvages to veins (muscovite or chlorite infill).

Chemical analyses were obtained on 36 sedimentary rock samples from along the granite-sediment contact, perpendicular to the north end of the contact and parallel to the contact. The data indicate that the major elements and most trace elements (REE, transition elements, HFSE, some LILE) have an unaltered chemistry when compared to results for Meguma Group lithologies from nonmineralized areas and fields in major and trace element discriminant diagrams. However, there is variable enrichment for Sn, Zn, Bi (?), Rb, Li and U which reflects the mineralogical features mentioned above.

The above observations suggest that a metal-rich fluid phase, presumably of granite derivation and related to the mineralizing process, did move through the wall rock metasediments. Given the lack of *bona fide* veins, fluid movement probably occurred along boundaries and structural anisotropies, thus accounting for the generally disseminated nature of the minerals produced by hydrothermal alteration and the continuity of whole-rock chemistry.

1 Funded by Nova Scotia Department of Natural Resources under the Canada - Nova Scotia Mineral Development Agreements (1984-1989, 1990-1992) and NSERC Operating Grant to J. Dostal

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PROGRESS REPORT ON A MULTI-MEDIA GEOCHEMICAL SURVEY AT THE DOMINIQUE Sn-Zn-Cu DEPOSIT, YARMOUTH COUNTY[1]

P. A. Lombard and F. J. Boner

A multi-media geochemical survey was conducted over the Dominique Sn-Zn-Cu deposit during the summer of 1991. The deposit is located approximately 6 km east of Yarmouth, Nova Scotia. Based on the results from previous diamond-drilling programs, a 1.5 x 0.7 km sampling grid was centred over projected zones of mineralization.

The Dominique deposit was chosen for this type of study based on the following geological controls: (1) A slate and greywacke till locally derived from the Goldenville Formation was deposited by a dominantly southern ice flow (Stea and Grant, 1982) and (2) The underlying bedrock unit in the entire area is the Goldenville Formation (Taylor, 1967). In addition, a 1991 drilling program conducted by the Department of Natural Resources within the survey grid will provide further information about the geology of the Dominique deposit.

Within the grid the following sample media were collected (100 m spacing) when available: tamarack (*Larix bricina*) bark, tamarack twigs, red spruce (*Picea rubens*) bark, red spruce twigs, Balsam fir (*Abies balsamea*) twigs and humus (A_1 horizon). The tree limb samples consisted of the last 5-9 years' growth, depending on the species. The tree bark samples consisted of approximately 350 g of dead outer bark scraped from the particular tree species. Within the same grid, on a 200 m spacing, a 3-5 kg sample of clast material (>1 cm) and a 5 kg sample of matrix material (<1 cm) were collected at 0.8-1.2 m depths in the unweathered C horizon.

After analytical results have been received and evaluated, recommendations on the multi-media samples will be determined. The project will determine which medium best illustrates the geochemical response of the deposit. This study can then be used as a comparison for Sn-Zn-Cu prospecting in similar metallogenic environments.

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Taylor, F. C. 1967: Reconnaissance geology of Shelburne map-area, Queens, Shelburne and Yarmouth Counties, Nova Scotia; Geological Survey of Canada, Department of Energy, Mines and Resources, Memoir 349, 83 p.

Stea, R. R. and Grant D. R. 1982: Pleistocene geology and till geochemistry of southwestern Nova Scotia (sheets 7 and 8); Nova Scotia Department of Mines and Energy, Map 82-10, scale 1:100 000.

1 Funded by Nova Scotia Department of Natural Resources under the Canada - Nova Scotia Cooperation Agreement on Mineral Development 1990-1992

PROGRESS REPORT ON A DETAILED GEOCHEMICAL STUDY OF THE Li-BEARING BRAZIL LAKE PEGMATITES, SOUTHWESTERN NOVA SCOTIA[1]

M. A. MacDonald, F. J. Boner and P. A. Lombard

Several detailed multi-media geochemical surveys, centred on known mineral occurrences throughout Nova Scotia, have been initiated as part of the current Canada - Nova Scotia funding agreement. One of these surveys focused on the Brazil Lake pegmatites, located approximately 30 km northeast of Yarmouth. These pegmatites have several characteristics that make them ideal for detailed geochemical study. These include: (1) the geological setting and contact relations between the pegmatites and surrounding country rocks are well constrained; (2) the presence of four pegmatite outcrops in the study area provides excellent control on the exact location of pegmatite bodies; (3) the chemical and mineralogical characteristics of the pegmatites differ substantially from those of their host rocks (mica-garnet schist, amphibolite, quartzite). Accordingly, the location of the pegmatites should be clearly demarcated by the distribution of select trace, and possibly major, elements; (4) the paucity of human activity in the area reduces the possibility of man-made contamination; and (5) the presence of a single, local, stony ground moraine that was deposited by a dominant southward ice flow. The lack of a complex glacial stratigraphy should facilitate the interpretation of geochemical data.

The Brazil Lake pegmatites are the only spodumene-bearing (Li-pyroxene) igneous rocks exposed in Nova Scotia and are interesting from both metallogenic and economic perspectives. Hutchinson (1982) noted the presence of, in order of decreasing abundance, quartz, albite, microcline, spodumene, muscovite, beryl, tourmaline, zircon, apatite, columbite, tantalite, biotite, epidote and cassiterite. The occurrence of this granitic mineral assemblage in narrow dykes, within a predominantly metasedimentary and metavolcanic terrane, provides a unique opportunity for surficial geochemical study. Concentrations of the granophile elements Li, Be, Rb, Ta, Nb and Sn, and possibly F, B, Zr, P_2O_5, Th and U, in till, humus and biogeochemical media over or near the pegmatites should be much higher than over the surrounding country rocks.

A sampling grid measuring 600 x 600 m and consisting of 169 sites on 50 m centres was established over three aligned pegmatite outcrops. Specimens collected at each site included the past 5-7 years' growth (twigs and branches) on Balsam fir and/or black spruce, depending upon species availability, and organic humus (A_1 horizon). A total of 49 till samples were collected at 100 m spacing throughout the grid. Approximately 3-5 kg of clasts (>1 cm) and 5 kg of matrix (<1 cm) were collected below the B soil zone (0.8-1.2 m depth). Analytical data are not yet available.

The objectives of this project include: (1) determination of the geochemical fingerprint of the pegmatites; (2) evaluation of the relative effectiveness of till, humus and biogeochemical sampling media. This will include cost effectiveness, ease of sampling, availability of sample medium in specific terrain and strength of anomaly/background contrast; and (3) estimation of the optimal geochemical technique(s) for exploration for additional rare-metal pegmatites and select granophile deposits in southwestern Nova Scotia.

REFERENCE

Hutchinson, H. E. 1982: Geology, geochemistry and genesis of the Brazil Lake pegmatites, Yarmouth County, Nova Scotia; unpublished B.Sc. thesis, Dalhousie University, Halifax, Nova Scotia, 95 p.

1 Funded by Nova Scotia Department of Natural Resources under the Canada - Nova Scotia Cooperation Agreement on Mineral Development 1990-1992

A STUDY OF ANGULAR VEIN RELATIONSHIPS AT TANGIER, NOVA SCOTIA[1]

R. F. Mills

Vein types in the Meguma zone vary greatly and at least seven main types of veins have been classified based on structure (Smith and Kontak, 1988). Stratabound veins are the most abundant vein type. However, angular veins at Tangier occur as irregular, bull-crosscutting, en-echelon and AC veins, and vary in size from stringers to veins 10 cm or more wide. As part of the study on the Tangier gold deposit an investigation was undertaken to evaluate the nature of angular veins in the ore zone, and their possible relationship to ore formation, if any.

A photographic library of diamond-drill core recovered over the ore zone was created by Coxheath Gold Holdings Ltd., as most of the core was destroyed by assaying procedures. This photographic library is being used to study 13 diamond-drill holes over the ore zone which are being used to illustrate a typical cross-section. The methodology involves noting the wide variety of characteristics of the veins on data collection sheets. The data are being used to draw histograms to investigate individual characteristics of veins relative to important factors such as mineralization, angle to stratification and others. Characteristics include the nature of the host rock, including type, color and texture. The nature of the vein is also noted, including color, texture, mineralization (if seen), presence of alteration products or minerals, the type of contact with the host, and vein thickness. Angular relationships to any well developed lineation that may develop in the host, such as pressure solution cleavage or brittle shear, are also being investigated, as well as relationships with any other veins that may develop (e.g. en-echelon vein systems, anastamosing veins, sheeted veins or veins that cut one another).

Unfortunately, a lot of detail is lost in the photographs, which are approximately 1/5 scale. Most structural relationships to veins, sometimes difficult to discern under the best conditions, cannot be seen on the photographs. Age relationships to deformational events, mineralization and alteration may or may not be observable. Relationships of the veins to regional folding, whether veins have an intersection lineation which is coaxial with the regional stratification or cleavage intersection, whether they are prior to ductile shear cleavage, or whether vertical or horizontal shear lineations are present in the host, can rarely be seen. Any features other than those noted on the data sheets are recorded in a comment section.

Preliminary results of the findings should be ready late in 1991 or early in 1992, followed by a data release and short report to accompany the findings.

REFERENCE

Smith, P. K. and Kontak, D. J. 1988: Meguma gold studies II: Vein morphology, classification and information, a new interpretation of 'crack seal' quartz veins; *in* Mines and Minerals Branch Report of Activities 1987, Part B, eds. D. R. MacDonald and Y. Brown; Nova Scotia Department of Mines and Energy, Report 88-i, p. 61-77.

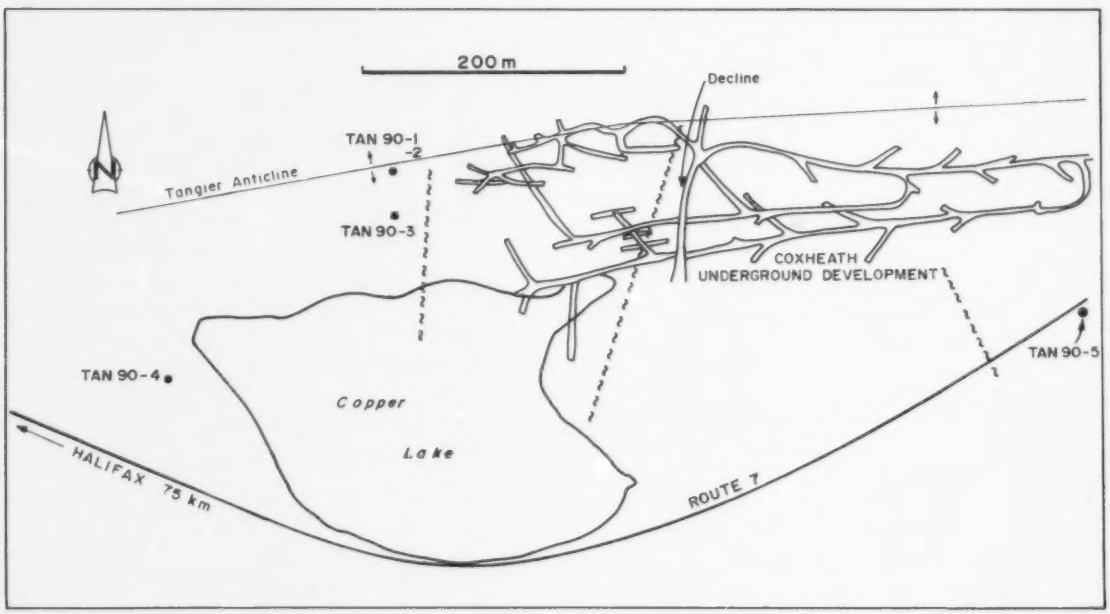
1 Funded by Nova Scotia Department of Natural Resources under the Canada - Nova Scotia Cooperation Agreement on Mineral Development 1990-1992

RELEASE OF NOVA SCOTIA DEPARTMENT OF NATURAL RESOURCES DIAMOND-DRILL HOLE DATA FROM TANGIER, NOVA SCOTIA[1]

R. F. Mills and M. C. Corey

The Tangier project was initiated in the summer of 1990 in order to compile all previous and current geological data regarding the Tangier mine and to investigate controls of gold mineralization at the Tangier gold deposit. Since virtually all of the core sections from the gold-bearing zones intersected by Coxheath Gold Holdings Ltd. (the current licensee for the mine) during extensive underground and surface diamond-drilling were destroyed by fire assay analysis, the only complete core sections available were from five holes drilled by the Sullivan Mining Group in 1983. This drilling information was verified and further supplemented with data compiled from five diamond-drill holes drilled at Tangier by the department (Fig. 1). One (TAN-90-1) was a short hole to locate the drill on the anticline that hosts the ore zone at Tangier. Another hole (TAN-90-5) was not drilled in proximity to the ore zone, but was spudded approximately 1.2 km north in an attempt to locate the old Kent workings. This hole was drilled to provide a section for perspective along strike and for the purpose of correlation with the main ore zone. The core has been saved, except for 29 geochemical samples taken for study from split core. This core will be preserved at the Nova Scotia Department of Natural Resources core library facility in Stellarton, Nova Scotia, and will be available for viewing by industry or other research agencies once the diamond-drill hole data have been released.

Data gathered from the holes drilled over the ore zone (TAN-90-1; TAN-90-2; TAN-90-3 and TAN-90-4) are currently being compiled for release with sections accompanying the drill logs. A short report will accompany the drill logs, sections and data compilation. The report should be available as an Open File Report by the spring of 1992.



1 Funded by Nova Scotia Department of Natural Resources under the Canada - Nova Scotia Cooperation Agreement on Mineral Development 1990-1992

DIAMOND-DRILLING OF THE METASEDIMENT-HOSTED DOMINIQUE Sn-Zn-Cu DEPOSIT, YARMOUTH COUNTY, NOVA SCOTIA[1]

G. A. O'Reilly

The Nova Scotia Department of Natural Resources has recently completed a four hole diamond-drill program at the Dominique Sn-Zn-Cu deposit located near Plymouth, 5 km east of Yarmouth. Boulders mineralized with economic concentrations of Sn, Zn, Cu, Pb, Mo and Ag were first recognized in the area of the old Dominique gold prospect during the exploration rush of 1976-1982 in southwest Nova Scotia. Further exploration, including diamond-drilling, by Shell Canada Resources Limited at the prospect and in the surrounding area resulted in discovery of high grade Sn-Zn-Cu-Pb mineralization within zones of intense chlorite, pyrrhotite and carbonate alteration in semi-pelite and wacke of the Cambro-Ordovician Goldenville Formation. Three separate Sn-rich zones were defined along east-trending shear zones that correspond with well defined geophysical anomalies. The Sn mineralization at the Dominique deposit is associated with chlorite-pyrrhotite-carbonate alteration. The style of the mineralization and the alteration mineral assemblage strongly resemble the metasediment-hosted Sn deposits at the Renison Bell Sn Deposit, Australia, and Andean deposits such as San Rafael, Peru, and the Kellhuani Sn deposits, Bolivia. A poor correlation of Sn mineralization between drillholes led Shell Canada Resources to suggest the zones represent steeply plunging, Sn-rich alteration pipes. The pipes formed from emanations migrating upward along the east-trending shear zones from a granite source similar to the nearby Wedgeport Pluton, which is similarly mineralized and altered.

Although the potential for economic tin and base metal mineralization at this and similar deposits remains high, there has not been any significant exploration since the early 1980s. In order to study this excellent example of metasediment-hosted Sn mineralization the Department of Natural Resources drilled four holes at the deposit. The main objectives of the drill project were to: (1) evaluate the application of the Sn-rich pipe model to this deposit, (2) provide material for detailed petrographic and geochemical studies and (3) examine for the extension of mineralization below that previously delineated. DOM 91-1 was drilled due north at -55° for 199 m to examine a geophysical (filtered resistivity) anomaly not previously drilled by Shell Canada. DOM 91-2 was drilled due south at -65° for 305 m and passed below the western end of the central of the three mineralized zones that constitute the deposit. Shell Canada Resources intersected several high grade zones in this area of the deposit. DOM 91-3 was collared immediately above the projected intersection of DOM 91-2 with the proposed east-trending mineralized shear zone and was drilled vertically to a depth of 306 m. DOM 91-4 was drilled due south at -76° for 184 m and was positioned to intersect a significant zone of Sn mineralization located immediately south of the central zone. This zone was first intersected, but poorly defined, by Shell Canada Resources (DDH 78-01). The drill core from the four holes is currently being logged. After that, several of the altered and mineralized zones will be sampled and analyzed for a suite of elements including Sn, W, Cu, Pb, Zn, As, Mo, Bi, Cd, In, Sb, Ag, Au, U, Th, F, Li, B and CO_2. The drill logs, geochemical data and a description of the drill results will be released as an Open File Report in the near future. More detailed petrographic, geochemical and isotopic studies will be incorporated in an overall study of metasediment-hosted tin and base metal deposits of the Southwest Nova Scotia tin domain.

1 Funded by Nova Scotia Department of Natural Resources and partially by the Canada - Nova Scotia Cooperation Agreement on Mineral Development 1990-1992

PROGRESS REPORT ON EXPLORATION GEOCHEMICAL STUDIES[1]

P. J. Rogers, M. A. MacDonald, F. J. Boner and P. A. Lombard

Most new fieldwork during 1991 was conducted under the Canada - Nova Scotia Cooperation Agreement on Mineral Development. Provincial geochemists completed detailed studies at Brazil Lake and Dominique (Fig. 1). Staff of the Geochemistry and Quaternary Section will present a number of poster displays as follows:

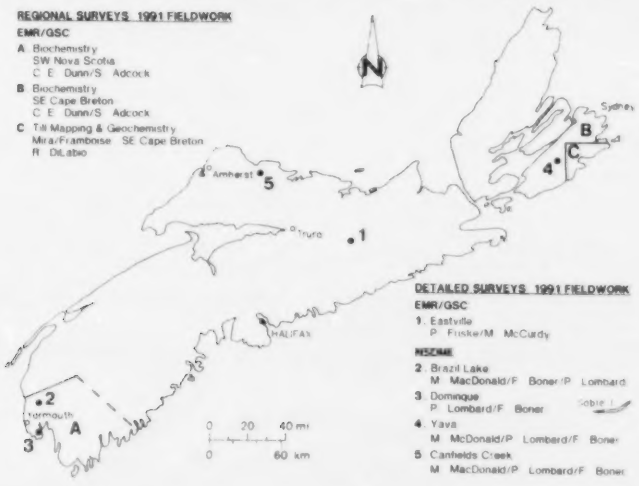
F. J. Boner will detail the processing of geochemical data for the Yava survey to include quality control, data reduction and surficial geology from till clasts.

P. A. Lombard will feature a detailed survey at the Dominique Sn deposit, Yarmouth County. A 1.5 x 0.7 km sampling grid with 100 m line spacing was used to collect humus, till and biogeochemical samples. He will also present Part 1 of the Geochemical Atlas of Nova Scotia (drainage surveys; OFM 90-015) which details colour and black and white maps for streams and lake sediments, and stream and lake waters. These maps will be presented with a focus on base metal geochemical trends in Nova Scotia.

M. A. MacDonald will discuss the surficial geochemistry of the Brazil Lake pegmatite. A 600 x 600 m sampling grid used a 50 m spacing to collect humus, till and biogeochemical samples. Preliminary results from heavy mineral separates from tills (-250 + 62.5 μm) will be presented and used to establish the geochemical parameters for the deposit.

P. J. Rogers will present results from previous biogeochemical sampling in the eastern Meguma Zone at the local scale as an aid to precious and base metal exploration. Partitioning of elements between various size fractions of till from the Scotsburn area of northern Nova Scotia indicate the need to consider hydromorphic effects when interpreting geochemical patterns at each site.

1990-2 GEOCHEMISTRY/QUATERNARY SECTION ACTIVITY AREAS



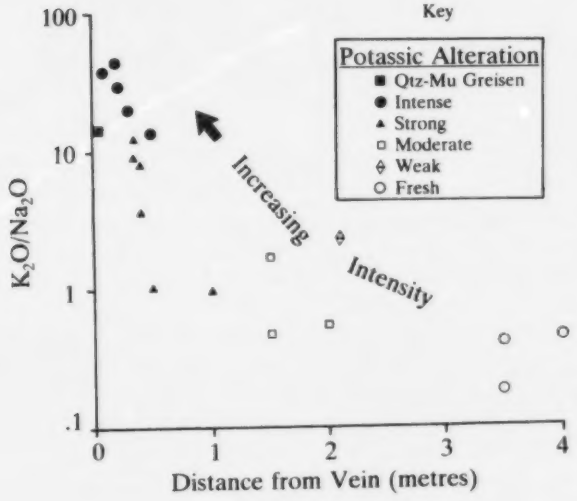
1 Funded by Nova Scotia Department of Natural Resources under the Canada - Nova Scotia Cooperation Agreement on Mineral Development 1990-1992

ALTERATION GEOCHEMISTRY ASSOCIATED WITH AURIFEROUS VEINS IN THE CAPE BRETON HIGHLANDS, NOVA SCOTIA: AN EXAMPLE OF K_2O ENRICHMENT

P. K. Smith, G. O'Reilly and M. L. Slauenwhite[1]

Widespread, strongly deformed, quartz-hematite-pyrite ± galena veins hosting gold mineralization in the Cape Breton Highlands occur primarily in mafic/felsic orthogneiss, augen gneiss and paragneiss (central unit). Amphibolite, chlorite schist, metavolcanics and orthogneiss lie to the west (west unit), and amphibolite with intercalated quartzite, calc-silicate, schist and marble lie to the east (east unit). Alteration throughout the region includes pervasive quartz-epidote development with smaller zones of associated epidote, chlorite and sericite. The intense development of biotite and sericite adjacent to quartz ± tourmaline veins is commonly associated with the highest grade of mineralization and is regarded as an effect of hydrothermal alteration during vein formation.

An example of K_2O enrichment associated with pervasive sericite development is given for the auriferous veins at Zone 6A, located on the McMillan Road. At this site, the geochemistry of the various alteration zones adjacent to the vein are tabulated and compared to their relatively fresh diorite host. A plot of K_2O/Na_2O against distance from the vein margin for 19 samples collected from the prospect shows extreme relative potassium enrichment, up to 2 m from the vein margin. This alteration style is considered a reliable indicator of elevated gold mineralization throughout the region and thus represents a potential exploration target for near-surface, auriferous veins. Alteration effects are especially enhanced where superimposed weathering has produced relatively large oxide zones.



Distance to vein	Increasing Alteration Intensity → FRESH>>>>>MODERATE>>V.STRONG>>QTZ-MU>>>> 3.50	1.50	0.50	0.00
Rock Type	DIORITE →			GREISEN
Sample #	CB91-1	CB91-2	CB91-3	CB91-4
SiO2 (%)	51.05	53.37	56.93	62.61
TiO2 (%)	0.82	1.04	1.17	0.32
Al2O3 (%)	16.97	19.93	23.00	22.24
Fe2O3 (%)	5.57	6.85	6.26	3.23
FeO (%)	4.90	5.57	0.41	0.75
MnO (%)	0.21	0.18	0.15	0.01
MgO (%)	5.25	2.98	0.75	0.83
CaO (%)	9.36	0.81	0.18	0.18
Na2O(%)	1.50	1.64	0.51	0.48
K2O (%)	0.61	2.77	6.81	6.79
P2O5 (%)	0.15	0.21	0.25	0.03
CO2 (%)	0.20	0.21	0.21	0.14
H2O - (%)	0.15	0.18	0.08	0.08
H2O + (%)	2.56	4.84	2.30	2.30
TOTAL	99.30	100.57	99.01	100.00
Fe2O3(t)	11.03	13.05	6.72	4.07
K2O/Na2O	0.41	1.69	13.35	14.15

1 INCO Exploration & Technical Services Inc., 2690-666 Burrard Street, Vancouver, British Columbia V6C 2X8

SURFICIAL GEOLOGY DATABASE AND MAP OF NOVA SCOTIA

R. R. Stea

The surficial geology map of Nova Scotia is in the final proof stage and will be published this year. The map is presented in colour at a scale of 1:500 000 and includes data on the nature, thickness and distribution of surficial deposits. The data are essential for environmental, engineering, agricultural and mineral exploration studies.

The map data are also available in digital form from the Land Survey and Registration Service (LRIS), Amherst, Nova Scotia, digitized at a scale of 1:250 000.

ACADIA UNIVERSITY: DEPARTMENT OF GEOLOGY

J. A. Colwell, Head

Acadia University is located in Wolfville, Nova Scotia, in the eastern Annapolis Valley about 100 km northwest of Halifax. The Geology Department consists of 7 full-time professors, 2 part-time lecturers, and 1 demonstrator. We have 29 undergraduate majors, 6 graduate students and two postdoctoral fellows. The Geology Department emphasizes an integrated field and laboratory approach and offers instruction and research training leading to the four-year degrees of Bachelor of Science and Bachelor of Science with Honours, and the Master of Science degree. Research funding mainly comes from faculty grants and contracts which are held by most staff. Full-time graduate students also hold fellowships.

RESEARCH PROJECTS IN NOVA SCOTIA

S. M. Barr - regional mapping and petrologic studies of volcanic and granitoid rocks, Cape Breton Island.
B. W. Cameron - vertebrate and invertebrate paleontology and trace fossils of the Horton Bluff, Wolfville, Blomidon and Scots Bay formations.
M. Doyon (PDF) - geology of the Stirling area, Cape Breton Island.
J. A. Colwell - geology of the North Mountain basalt.
D. W. A. McMullin (PDF) - geological correlations between Nova Scotia and Newfoundland.
R. G. Moore - geological mapping in the Cogmagun River - Goshen areas, Hants County; biostratigraphy of the Windsor Group.
R. P. Raeside - regional mapping and tectonics of Cape Breton Island; metamorphic petrology of Meguma terrane.
G. R. Stevens - interpretation of sidescan radar imagery of the Gaspereau Lake - Windsor area; meteor impact structure.
N. A. Van Wagoner - the Fourchu Group and associated granitoid rocks, Cape Breton Island; the Stirling sulphide deposit.

Theses related to Nova Scotia geology in progress

Petrogenesis of anorthosite and associated rocks in the Blair River Complex, northern Cape Breton Island (Robert Bekkers - M.Sc.)
Petrology and economic potential of gabbroic plutons in southeastern Cape Breton Island (Anastassios Grammatikopoulos - M.Sc.)
Geology of the Blair River Complex, Cape Breton Island (Brent Miller - Ph.D. with Dalhousie)
Stratigraphy, structure and metamorphism of the Cape North and Money Point groups, Cape Breton Island (Adoon Wunapeera)

ST. FRANCIS XAVIER UNIVERSITY: DEPARTMENT OF GEOLOGY

J. B. Murphy, Chairman

St. Francis Xavier University is located in Antigonish, about 250 km east of Halifax. The geology department consists of five staff members and visiting faculty. Our program is designed to provide a strong fundamental background for students who wish to continue to graduate studies, provide training to equip those who go to work as professional geologists and offer non-geologists a chance to learn about our planet. In the 1991-92 academic year, our program has over 300 full course equivalent registrants. The geology curriculum of the department reflects the above aims. Courses such as Mineralogy, Crystallography, Petrology, Stratigraphy and Sedimentation, and Structural Geology are basic. Applied courses include Ore Deposits, Petroleum Geology, Coal Geology, Geophysics and Geochemistry. The latter provide an opportunity to use and elaborate on the basic principles encountered in earlier geology courses and courses obtained outside this department, especially physics, chemistry and mathematics. There is a seminar course for senior students that is directed to developing the students' capacity to formulate, devise, and execute a research topic. All major and honours students are required to write a thesis under the supervision of a faculty member.

Field studies are viewed as the most important means of laboratory instruction. To bring together textbook and actual occurrence, certain laboratory periods are devoted to examination in the field. This is subject to seasonal restrictions. In a number of branches of earth science, three-dimensional visualization in Mineralogy and Structural Geology is promoted through the use of descriptive geometry and stereographic projection. Other aspects of laboratory work include the examination of hand specimens and thin sections under the petrographic microscope, analyses of structures on maps, and geochemical analyses including work on radiometric dating of rocks.

At the end of the sophomore year all students are strongly urged to attend the 10-day spring field camp held annually at St. Francis Xavier University. The camp forms the core of the Field Methods course which also involves numerous mapping projects during sophomore, junior and senior years. In addition, many geology students obtain employment in geological work during the summer. This is regarded as an effective extension of their classroom and laboratory experience.

All faculty are encouraged to maintain a rigorous research program. Over 40 fully refereed articles have been published by our faculty since 1989.

Alan J. Anderson, Ph.D., (Queens) Economic Geology, Mineralogy and Introductory Petrology.
R. F. Cormier, Ph.D., (M.I.T.) Geochronology, Petrology.
Wes Gibbons, Ph.D., (Plymouth) Visiting as James Chair Professor.
Michael J. Melchin, Ph.D., (Western) Paleontology, Sedimentology.
J. Brendan Murphy, Ph.D., (McGill) Chairman, Tectonics, Structural Geology.
Gary Yeo, Ph.D., (Western) Stratigraphy, Sedimentology.

SAINT MARY'S UNIVERSITY: GEOLOGY DEPARTMENT

G. Pe-Piper, Chairperson

The Geology Department of Saint Mary's University offers a complete undergraduate program leading to geology major and honours degrees. In addition to the range of geological disciplines taught within the department, students may study subjects cross-listed by the departments of Chemistry and Geography. Combined major and honours programs in geology and geography are also offered. Courses offered by the department also support the degree programs of departments such as Geography, Chemistry, Anthropology and the Atlantic Canada Studies program. In addition to the normal academic programs, the department offers a Co-operative program in both Geology and Geography, in which students are employed in geology-related positions as part of their degree requirements.

The department consists of five full-time and three part-time faculty members and two adjunct professors, from the Geological Survey of Canada and the Nova Scotia Department of Natural Resources. The department is an integral part of the Atlantic Canada Centre for Environmental Science (ACCES) at Saint Mary's University. It also houses the Regional Geochemical Centre with two full-time technicians. This centre consists of X-ray fluorescence and Instrumental Neutron Activation Analysis facilities that the department operates on behalf of a consortium of five Maritime universities. Research in the department is funded largely through the Natural Sciences and Engineering Research Council (NSERC), other government agencies, and contracts.

FACULTY RESEARCH PROJECTS (HIGHLIGHTING RECENT WORK IN NOVA SCOTIA)

J. Dostal - igneous petrology; geochemistry (cooling history and differentiation of North Mountain basalts; Silurian-Early Devonian evolution of the northwestern mainland Appalachians; geochemistry of mineralized and barren Proterozoic felsic volcanic rocks of Nova Scotia; trace element mobility during alteration of granitic rocks, particularly on the South Mountain Batholith).
J. V. Owen - metamorphic petrology, structural geology (investigation of crystalline rocks in eastern Canada, recent work centres on 1 billion year old granites in Labrador; migmatitic rocks in western Quebec; and crustal xenoliths from the Dunnage zone, Newfoundland).
G. Pe-Piper - igneous petrology, mineralogy, geochemistry (volcanic evolution and hydrothermal alteration of the Fountain Lake Group, western Cobequid Highlands; petrogenesis, geochemistry and mineralization of the A-type granites of the Cobequid Highlands; plutonic and other basement rocks from the Scotian Shelf and their regional significance).
Q. A. Siddiqui - micropaleontology, biostratigraphy (present work centres on some Cretaceous deep water ostracods obtained by the Ocean Drilling Program in the Weddell Sea, Antarctica; and establishing a data-base for ostracods from cold marine and marginal marine waters of the eastern Canadian Arctic).
J. W. F. Waldron - structural geology; sedimentology (present work centres on stratigraphy and sedimentation of the Meguma Group, including fossil debris from Goldenville Formation in Mahone Bay; Carboniferous sediments and structure adjacent to the Cobequid-Chedabucto fault zone; and Paleozoic tectonic history of the west Newfoundland Appalachians, with emphasis on Acadian thrusting and its effect on Taconian structure and sedimentary basins).

RECENTLY COMPLETED AND CURRENT B.SC. THESES

R. E. Corney B.Sc. 1991 - Sedimentation at the Appalachian Thrust Front, Port au Port Peninsula, western Newfoundland. **S. Guimond-Palmer** B.Sc. 1991 - Carbonates and associated sediments in the Merigomish Formation of the Stellarton Gap, Nova Scotia. **J. Selway** B.Sc. 1991 - The petrology, geochemistry, and a detailed map of the Pleasant Hills pluton in the Cobequid Highlands, Nova Scotia. **J. Nearing** - Carboniferous hydrothermal events, western Cobequid Highlands. **H. Pancura** - Hydrothermal alteration and volcanic evolution of the Fountain Lake Group, Cape Chignecto, western Cobequid Highlands. **D. Pass** - Carboniferous structural evolution of Cobequid plutons revealed by successive dyke emplacement.

DALHOUSIE UNIVERSITY: DEPARTMENT OF GEOLOGY STUDENT RESEARCH IN NOVA SCOTIA

P. H. Reynolds, Graduate Co-ordinator

INTRODUCTION

Dalhousie University in Halifax is well situated and well equipped for research in a range of Earth Science disciplines. The department includes 14 full-time faculty members and 6 university technicians, with 13 Ph.D., 15 M.Sc. and 7 B.Sc. honours students (final year) registered in 1991-92.

The Department offers research projects in four general subject areas: (i) Petrology and Geochemistry, (ii) Sedimentary Geology and Micropaleontology, (iii) Tectonics, and (iv) Thermochronology. Many faculty members and their students are involved in research in Nova Scotia or its adjacent continental margin. Research is funded largely through the Natural Sciences and Engineering Research Council (NSERC), other government agencies, and contracts; most graduate students hold scholarships or fellowships paid from University and/or research funds.

Research equipment includes a JEOL Superprobe, now upgraded with an image analysis system (run as a regional facility), conventional and laserprobe $^{40}Ar/^{39}Ar$ dating facilities, a fission track lab (the only university facility of its kind in Canada), X-ray diffraction, atomic absorption and volatile analysis equipment, a high pressure seismic velocity lab, a stable isotope lab, a paleomagnetism lab, and a wide range of geophysical, sedimentological, micropaleontological, computing, petrographic, sample preparation, and photographic equipment. In addition, department members have access to the regional X-ray isotope facility (AURIF) now being set up at Memorial University of Newfoundland.

THESIS RESEARCH IN NOVA SCOTIA: 1989-91

J. Jennings (B.Sc.) 1989. A geophysical study of the Liscomb Satellite Pluton, central Nova Scotia.
K. McKillop (B.Sc.) 1989. Fission track study of the Jubilee deposit, Cape Breton Island, Nova Scotia.
A. Grist (M.Sc.) 1989. Provenance and thermal history of detrital sandstones of the Scotia Basin, offshore Nova Scotia, using the apatite fission track and $^{40}Ar/^{39}Ar$ methods.
K. Billard (B.Sc.) 1990. Geophysical modelling of the LaHave Clay and Emerald Silt formations, LaHave Basin.
H. McLaughlin (B.Sc.) 1990. Thermobarometry of the metasedimentary enclaves in the Ten Mile Lake intrusion, Liscomb, Nova Scotia.
B. Laidler (M.Sc.) 1990. Distribution of foraminifera and thecamoebans in sediments of Porters Lake, Halifax County.
T. Martel (Ph.D.) 1990. Stratigraphy, fluviolacustrine sedimentology and cyclicity of the Late Devonian/Early Carboniferous Horton Bluff Formation, Nova Scotia, Canada.
G. Gallant (B.Sc.) 1991. Origin of foliation in the Barrington Passage pluton.

SPECIFICATIONS OF EARTH RESOURCES SATELLITES AND THEIR UTILITY FOR GEOLOGICAL INVESTIGATIONS IN NOVA SCOTIA

M. S. Akhavi[1]

Earth resources satellites have been used at the College of Geographic Sciences for more than a decade to assist in geological exploration and environmental monitoring of various parts of Nova Scotia. Synoptic and repetitive coverage, multispectral sensitivity, and high resolution are among the advantages of spaceborne imagery.

The Landsat Thematic Mapper (TM) covers a broad portion of the electromagnetic spectrum and consists of seven discrete bands covering visible, reflected and thermal infrared regions. Six of the reflective TM bands have a resolution of 30 m^2; whereas band 6, which covers the thermal region of the electromagnetic spectrum, has a resolution of 120 m^2. Landsat data are utilized for (1) surficial geology investigations, peat and aggregate resource mapping; (2) bedrock geology, lineament, and structural mapping; (3) geocoded database integration utilizing a GIS environment; (4) engineering terrain mapping and digital elevation modelling; (5) coastal and fluvial geomorphic mapping and detection of river bank mass wasting; and (6) hydrogeological and water resources applications.

In 1986, with the emergence of the French satellite SPOT, a new era in remote sensing from space was initiated. SPOT's multispectral 'push-broom' scanner consists of three bands with a resolution of 20 m^2 while a panchromatic band provides a high resolution of 10 m^2. Stereoscopic imaging and successive day 'revisit' capabilities of this satellite are pertinent to dynamic or catastrophic geological monitoring. So far, SPOT data have been utilized for geomorphic and river bank mass wasting investigations of the lower part of the Annapolis River.

The 1990s will be the decade of spaceborne radar because five synthetic aperture radar systems will operate from space. The prospect of repetitive coverage from orbital radar systems holds considerable potential for geological exploration and environmental monitoring of Nova Scotia in a systematic manner.

Since being founded in 1978, graduate students and faculty at our college have completed over 50 projects in the field of geology and earth resources exploration with the direct cooperation of outside agencies. More than 20 external publications and open file reports have been generated based on the results of our cooperative project activities in Nova Scotia. The contributions of private sector, government, and academic institutions have been vital for making these cooperative projects meaningful and useful.

You are invited to participate in our cooperative program. Please address your questions and inquiries directly to the author of this article, Dr. M. S. Akhavi, if you would like to act as an external advisor or cooperative agency during this academic year.

1 Remote Sensing Program, College of Geographic Sciences, R.R.# 1, Lawrencetown, Nova Scotia B0S 1M0

REVISION OF UPPER PRECAMBRIAN - CAMBRIAN STRATIGRAPHY, SOUTHEASTERN CAPE BRETON ISLAND[1]

S. M. Barr[2], C. E. White[2] and A. S. Macdonald[2]

Combined mapping, petrological studies, and geochronology have resulted in revision of uppermost Precambrian to Cambrian stratigraphic units and their distribution in southeastern Cape Breton Island. A volcanic and sedimentary unit (Main-a-Dieu sequence) of latest Precambrian age has been recognized that is distinct, at least in rock types and deformational history, from the Fourchu Group. The upper part of the Main-a-Dieu sequence is characterized by laminated siliceous siltstone and volcanogenic conglomerate and sandstone, locally interlayered with amygdaloidal basalt, rhyolite, and felsic to intermediate lithic tuff. North, east, and south of the Mira River, a dominantly red clastic sedimentary unit, with distinctive quartzite/quartz-pebble conglomerate at its base, disconformably overlies the Main-a-Dieu sequence. The Precambrian-Cambrian boundary is located within this redbed unit. The redbed unit is overlain by quartz arenite with local conglomeratic (quartz pebble) lenses, in turn overlain by grey and green siltstone and shale of the middle Lower Cambrian MacCodrum Formation and red-brown, carbonate-rich mudstone and siltstone, maroon siltstone, and minor pink to red limestone of the upper Lower Cambrian Canoe Brook Formation. Mineralized skarns in the Blue Mountain area are developed in carbonate-rich rocks of the Canoe Brook Formation. Overlying formations are the lower Middle Cambrian Trout Brook Formation (dark grey to rust-brown, well cleaved shale and siltstone), the Middle Cambrian MacLean Brook Formation (interbedded grey quartz sandstone, siltstone, and shale), and the Upper Cambrian MacNeil Formation (dark grey shale, siltstone, and limestone).

Southwest of the Mira River, Precambrian volcanic and sedimentary rocks of the Stirling belt are overlain by arkosic sandstone, conglomerate, and wacke, assigned to the redefined Upper Precambrian to Lower Cambrian Kelvin Glen Group. Overlying the Kelvin Glen Group, we recognize units that appear to be equivalent to the Lower and Middle Cambrian MacCodrum, Canoe Brook, Trout Brook and MacLean Brook formations. Felsic and mafic igneous units in this area, previously interpreted to be flows, are younger (Devonian?) intrusions, and no volcanic rocks are present in the uppermost Precambrian or Cambrian units in the Mira River area. Units west and east of the Mira River correlate only after the mid-Early Cambrian, suggesting that the two areas were separate sedimentary basins prior to that time.

Middle and Late Cambrian to Early Ordovician rocks occur in the southern and central parts of the Boisdale Peninsula. On the basis of rock type, Middle Cambrian units in the southern Boisdale Peninsula most resemble the MacLean Brook Formation of the Mira River area. These rocks are overlain by shale and limestone (MacNeil Formation) and siltstone and sandstone that may be Ordovician in age. Cambrian rocks in the central part of the Boisdale Peninsula occur in a narrow, fault-bounded, northeast-trending belt. Structurally complex relationships exist, both within the lowermost unit (the Middle Cambrian Bourinot Group) and between the Bourinot Group and adjacent Middle Cambrian through Lower Ordovician units. A continuous stratigraphic succession does not appear to be present. The Middle Cambrian volcanic and sedimentary rocks exposed in the central Boisdale Peninsula are lithologically distinct from rocks of similar age elsewhere in southeastern Cape Breton Island.

Absolute ages and stratigraphic correlations may be resolved by U-Pb dating, currently in progress, of felsic volcanic units in the central Boisdale Peninsula and the Mira River area.

1 Funded by the Geological Survey of Canada under the Canada - Nova Scotia Cooperation Agreement on Mineral Development, 1990-1992

2 Department of Geology, Acadia University, Wolfville, Nova Scotia B0P 1X0

ANORTHOSITE AND RELATED ROCKS IN THE BLAIR RIVER COMPLEX, NORTHERN CAPE BRETON ISLAND, NOVA SCOTIA[1]

R. P. Bekkers[2] and B. V. Miller[3]

Continued mapping of the Blair River Complex (BRC) during 1991 has yielded more data and new interpretations. The BRC is predominantly composed of quartzofeldspathic, amphibolitic, and granitic orthogneiss, and minor paragneiss intruded by anorthosite, syenite, monzodiorite and granite. The syenite has yielded a U-Pb (zircon) metamorphic age of ca. 1040 Ma and a model igneous age in the range 1100-1500 Ma, thus providing a minimum age for the BRC. Based on lithologic and age similarities with portions of western Newfoundland, the BRC is thought to represent an extension of Grenvillian-type rocks into Cape Breton Island. Perhaps the most distinguishing of these Grenvillian-type rocks are the various anorthositic bodies in the BRC.

The main body of anorthosite in the area, the Red River Anorthosite Complex lies adjacent to the southeastern boundary of the BRC. This anorthosite complex outcrops in a pattern suggesting a nearly flat-lying contact with the gneisses of the BRC. It is not clear if this contact is of igneous or tectonic origin.

The Red River Anorthosite Complex is typified by massive white anorthosite and a unit of anorthositic gabbro interlayered with anorthosite on a 2-4 cm scale. The latter unit locally has K-feldspar-rich and granitic layers. A weakly layered monzodioritic unit lies immediately west of the main body of the anorthosite complex. These three units have cumulate textures and gradational contacts and are therefore thought to be genetically related. They have undergone amphibolite facies metamorphism, which is manifested in the retrogression of original high-grade ferromagnesian minerals to amphibole and chlorite. Deformation associated with this metamorphism has produced a mineral lineation oblique to the remnant igneous layering as well as minor intrafolial drag folding.

Anorthosite in the Red River Anorthosite Complex is typically composed of plagioclase (An_{35-50}) with some amphibole $\pm$ pyroxene and accessory biotite, quartz, titanite, apatite and zircon. Plagioclase grain size generally ranges from 1 to 5 mm with some grains exhibiting porphyroclastic to recrystallized granoblastic textures. Relict igneous pyroxene is rarely preserved in the cores of some amphiboles in the more mafic portions.

Other anorthositic igneous bodies occur throughout the Blair River Complex and are thought to represent small intrusions or dykes. A body of anorthositic gneiss appears to have been regionally metamorphosed along with the older gneiss units and is therefore thought to represent an older generation of anorthosite.

1 Funded by EMR Research Agreement and Natural Sciences and Engineering Research Council Operating Grants

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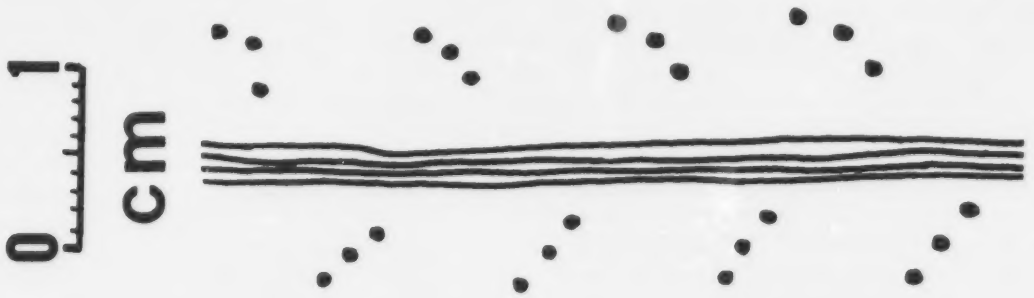
DISCOVERY OF TOURNAISIAN (EARLY CARBONIFEROUS) AQUATIC SCORPION TRACKWAYS IN THE HORTON BLUFF FORMATION[1]

B. Cameron[2], *D. Domanski*[3] *and R. Van Dommelen*[2]

Trackways similar to those of recent scorpions occur with other trace fossils in the coastal exposures of the Middle Member of the Horton Bluff Formation at Blue Beach, Nova Scotia. Our materials come from the cyclic, lacustrine "Blue Beach" member as described by A. T. Martel (1990). These Tournaisian-aged specimens may be the second oldest known scorpion trackways - the oldest being Devonian in age from Antarctica.

These trackways are nearly identical to *Paleohelcura tridactyla* Gilmore (1926), from the Permian Coconino Sandstone of northern Arizona, which are now ascribed to scorpions. Associated small fish trace fossils are delicately preserved on one slab, suggesting that these scorpions were at least occasionally aquatic. The fish traces are represented by discontinuous, continuous and paired sinusoidal wave traces similar to the fin and tail drag marks of the ichnogenus *Undichna* Anderson (1976). The oldest known scorpion body fossils from Silurian and Devonian rocks have also been reported as representing aquatic organisms.

The Horton Bluff *Paleohelcura* consist of two rows of footprints separated by discontinuous to continuous tail(?) drag marks. The footprints, ranging from 1 to about 2.8 mm in diameter, usually occur in clusters of three that alternate from one side of the tail(?) drag to the other, forming a trackway 1.5 to 2.2 cm wide. The footprints are circular to oval-shaped, dimple-like depressions when preserved on upper bedding surfaces in negative epirelief. They are round to oval bumps when preserved on lower bedding surfaces in convex (=positive) hyporelief. The footprint clusters usually form an acute angle with the tail(?) drag which may be more than a single groove. A portion of one trackway, preserved in convex hyporelief, is illustrated in the drawing below:



1 Funded by Acadia University Faculty Association Research Grant
2 Department of Geology, Acadia University, Wolfville, Nova Scotia B0P 1X0
3 6033 Willow Street, Halifax, Nova Scotia B3K 1L8

CONTRIBUTIONS TO THE VERTEBRATE PALEONTOLOGY OF THE MIDDLE MEMBER OF THE LATE DEVONIAN/EARLY CARBONIFEROUS HORTON BLUFF FORMATION[1]

B. Cameron[2], D. Domanski[3], P. D. White[2], R. Van Dommelen[2], S. MacConnell[2], D. Rogers[2], J. R. Jones[2] and B. McDonald[2]

The authors are collaborating on the preparation and study of our separate and joint collections of vertebrate body fossils and trace fossils from coastal exposures of the Middle Member of the Horton Bluff Formation at Blue Beach and Horton Bluff, Nova Scotia. Our materials include cranial and post-cranial skeletal elements of fish, possible amphibian remains, amphibian footprints, fish trace fossils and coprolites from the cyclic, lacustrine "Blue Beach" and "Hurd Creek" members, as described by A. T. Martel (1990).

Newly collected, isolated large clavicles, interclavicles, cleithra, an ulna, a brain case, fragments of vertebrae, ribs and small limb bones are being studied. Most of these skeletal elements probably belonged to the large rhipidistian crossopterygian fish *Rhizodus hardingi* (Dawson) which is represented also by a large jaw fragment and many isolated tusk-like teeth.

Fish trace fossils are represented by fin and tail drag marks. Some of these tool-like marks may be atributed to acanthodian fish which are represented skeletally by fin spines, such as *Acanthodes*. Other possible fish traces consist of a series of discontinuous to continuous and paired sinusoidal wave marks. Some of the latter are attributable to the ichnogenus *Undichna* Anderson (1976).

Amphibian fossils are very rare in the Horton Bluff Formation, except for their footprints which are the oldest known amphibian footprints in North America and the best preserved amphibian footprint assemblage in the world. The amphibian body fossils from the Horton Bluff Formation known to us suggest the presence of a seymouriamorph anthracosaur. The footprints being studied indicate a diverse assemblage of tetrapods existed during the Tournaisian (Early Carboniferous) in Nova Scotia.

1 Funded by Acadia University Faculty Association Research Grant
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GEOCHEMISTRY OF MINERALIZED AND BARREN LATE PROTEROZOIC FELSIC VOLCANIC ROCKS IN SOUTHEASTERN CAPE BRETON ISLAND

J. Dostal[1], *J. D. Keppie and M. Zhai*[1]

Late Proterozoic volcanic rocks of southeastern Cape Breton Island occur in several fault blocks (from southeast to northwest: Coastal, Stirling, East Bay Hills and Coxheath). The blocks are composed mainly of late Proterozoic volcanic suites which are predominantly bimodal and were emplaced in a volcanic arc setting. The basaltic rocks range from tholeiitic (Coastal and Stirling) to calc-alkalic (East Bay Hills and Coxheath). The felsic volcanic rocks of the Stirling block host a massive sulphide deposit but no economic mineralization has been discovered in the volcanic rocks of the other blocks.

The felsic volcanic rocks display significant differences in composition amongst the fault blocks. The Coastal and Stirling blocks contain low-K rhyolites with low abundances of strongly incompatible trace elements and relatively flat chondrite-normalized REE patterns. These rocks were probably derived by the melting of mafic igneous rocks compositionally similar to tholeiitic basalts of Archean greenstone belts or island arc tholeiites. Compared to the Coastal block rocks, the Stirling rhyolites are depleted in Eu, Sr and Al_2O_3 indicating extensive feldspar fractionation. Trace element characteristics of the Stirling block rhyolites are closely comparable to those of the Archean felsic metavolcanic rocks from the Superior Province of the Canadian Shield which are preferentially associated with massive sulphide mineralization. The similarities suggest that the low-K felsic volcanic rocks with flattish REE patterns and negative Eu and Sr anomalies are also indicative of a promising environment for massive base-metal sulphide mineralization in volcanic belts at least as young as late Proterozoic. The rhyolites of the Coxheath block have calc-alkalic affinities, higher contents of strongly incompatible elements than the Coastal and Stirling rhyolites, and their REE patterns are enriched in light REE. The East Bay Hills felsic tuffs resemble the Coxheath rhyolites. They both could be derived by melting of a source with a composition of the average lower crust.

1 Department of Geology, Saint Mary's University, Halifax, Nova Scotia B3H 3C3

GEOLOGICAL ENVIRONMENT OF THE STIRLING VOLCANOGENIC MASSIVE SULPHIDE DEPOSIT, SOUTHEASTERN CAPE BRETON ISLAND[1]

M. Doyon[2] and N. A. Van Wagoner[2]

The Stirling Zn-Pb-Cu-Ag-Au deposit lies in the northeastern half of the Stirling belt and was the site of the Mindamar Mine. This project is a detailed study of the northeastern half of the Stirling belt, concentrating on stratigraphy, physical volcanology, facies analysis and lithogeochemistry. It also comprises a study of the mineralization and alteration at the Stirling deposit and other showings. The goal of this project is to provide guidelines for exploration in similar rocks in the Avalon terrane.

During summer of 1991, detailed geological mapping was undertaken in the northeastern part of the Stirling belt. This part of the belt is shown to be composed mostly of sediments with interbedded volcanic rocks. The sediments are principally fine to conglomeratic sandstones with varying proportions of volcanic fragments, and locally show slump structures. There are also massive to sandy dolomites. Felsic flows form quartz and feldspar-phyric massive domes. Volcaniclastics are primary and reworked. Mafic sheets are abundant in the Stirling belt and in many cases it is not clear whether they are intrusive or volcanic; some sheets are also observed in the cover rocks and are intrusive. Bedding attitudes in the northeastern part of the Stirling belt are consistent with folding around a northeasterly-plunging fold axis. Schistosity and shear zones trend northeast. The Stirling deposit is cut by one of those shear zones.

We discovered a new sulphide showing 2 km northeast of the Stirling deposit and apparently lying at the same stratigraphic level. This showing is less deformed than the Stirling deposit and shows the relation between a 10 cm thick massive sulphide bed and an alteration zone within the underlying rhyolite. The fresh rhyolite is dark grey; it is bleached to a pale grey in a 40 m wide zone near the showing. There is a 10 m wide zone of brecciated rhyolite directly under the massive sulphides, composed of pale grey rhyolite fragments set in a dark matrix. The massive sulphides show bedding and are overlain by siltstone containing sulphide-rich laminae. Similar sulphide-rich laminae have also been observed at the Caledonia Road showing. Study of the core drilled on the Stirling deposit during the 1980s is in progress.

1 Funded by the Geological Survey of Canada under the Canada - Nova Scotia Cooperation Agreement on Mineral Development 1990-1992
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LATE CARBONIFEROUS PALEOVALLEYS IN THE SYDNEY COALFIELD[1]

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Thick sandstone (channel) bodies commonly overlie economic coal seams in the Sydney coalfield (Robb, 1876). The topmost coal layers have been eroded locally beneath the sandstone bodies, and linear coal "thins" mapped in mines probably represent thalweg positions of the river channels in which the sands were laid down. The height of mineable coal faces is thus reduced. The Bonar to Point Aconi seam interval was selected for analysis of channel body distribution.

Systematic lateral variation was observed at channel level. At Alder Point, a channel body rests on an 80 cm rider seam above the Bonar Seam, cutting out 50 cm of coal locally. However, the lowermost channel body is 1-2 m above the rider seam 1 km to the NW (east end of the Brogan Pit) and 18 m above the seam a further 2 km NW (Bras d'Or Channel). At Bonar Head, 4 km SE of Alder Point, an exceptionally thick (10 m) red mudstone caps 20+ m of grey floodplain strata that overlie the Bonar Seam; channel bodies are absent.

Channel bodies also show a systematic upward evolution in abundance, thickness and sedimentary structures. At Alder Point and Brogan Pit east end, three or four channel bodies (individually up to 8 m thick) form a 20 m, channel-dominated unit above the rider seam. The channel bodies are partially amalgamated, cutting locally into those beneath them. Lower channel bodies are thick and trough cross-bedded, whereas higher bodies are thinner and mainly plane-bedded. Red and grey floodplain mudstones at higher levels contain few, non-connected channel bodies that are mainly plane-bedded.

The systematic lateral and upward variation in channel body style and geometry indicates that the bodies form components of a paleovalley about 8 km wide and 20 m deep centred at Alder Point. Incised, dune-filled channels evolved progressively into shallower, ephemeral channels as the paleovalley filled. Thick, conglomeratic channel bodies that overlie the Bonar Seam at Swivel Point (Sydney Harbour) and at Low Point (New Waterford) probably formed in a second paleovalley to the SE. The thick red mudstones at Bonar Head are interpreted as mature soils (vertisols) on interfluves between paleovalleys. Valley incision probably reflects sea-level lowering associated with the coeval Gondwanan Glaciation.

Thus, thinning of the Bonar rider seam appears localized to the paleovalley centre where thick channel sandstone forms the roof rock. Thinly interbedded sandstone and shale (floodplain deposits) forms the roof rock beneath paleovalley margins and interfluves.

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COOLING HISTORY AND DIFFERENTIATION OF A THICK NORTH MOUNTAIN BASALT FLOW

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A thick (<175 m) North Mountain Basalt flow at McKay Head shows ~ 25 cm thick differentiated layers separated by ~ 130 cm of basalt in its upper 34 m. Upper layers (~5 m below the lava top) are highly vesicular whereas lower ones are pegmatitic and contain a thin (~2 cm) rhyolite band. The layering of the flow closely resembles that of some Hawaiian lava lakes. The vesicular basalts and mafic pegmatites are inferred to be liquid-rich segregations drained into horizontal cracks that form within a crystalline mush. The cracks resulted from a thermal contraction associated with cooling and shrinkage of the mush. Rhyolites were formed by *in situ* differentiation. Gas overpressures fractured the pegmatites and gas effervescence filter-pressing forced silica-rich residual liquid from pegmatite interstices into the fractures, creating bands. Chemical differences between the pegmatitic layers and early-formed, highly differentiated, upper vesicular layers may reflect a role for volatiles in the differentiation process along with crystal fractionation.

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THE DISCOVERY OF A CONGLOMERATE AT THE BASE OF THE CHETICAMP LAKE METAMORPHIC SUITE AND ITS IMPLICATION FOR THE GEOLOGICAL INTERPRETATION OF CAPE BRETON ISLAND, NOVA SCOTIA[1]

S. Lin[2], P. F. Williams[2] and R. P. Raeside[3]

Recent work suggests that the pre-Carboniferous of Cape Breton Island comprises four tectonostratigraphic terranes. They are, from NW to SE, the Blair River Complex, the Aspy terrane, the Bras d'Or terrane and the Mira terrane. Although there is good evidence that the Blair River Complex and the Mira terrane can be correlated with the Grenville basement and the Avalon terrane, respectively, the relationships between the other two terranes and these two terranes are not clear (Barr and Raeside, 1989). The discovery of a conglomerate at the base of the Cheticamp Lake Metamorphic Suite may help to solve the problem.

The conglomerate is paraconformable on the McMillan Flowage Formation in Warren Brook. Outcrop in the surrounding area is almost continuous for several kilometres and the contact is well exposed. The contact marks a drastic change in lithology from McMillan Flowage Formation on the east to the Cheticamp Lake Metamorphic Suite on the west. Immediately to the east of the contact a dark amphibolite is exposed for several hundred metres along the brook. Farther to the east is a dark amphibolitic biotite schist and a deformed diorite, which is in fault contact with the Cameron Brook Granodiorite. The conglomerate is exposed along the brook for about 100 m immediately to the west of the contact. The pebbles in the conglomerate are quartzite and granitic gneiss in about equal quantities. Both of these lithologies are unlike any rocks exposed in the vicinity. The gneiss has a foliation that is discordant with the bulk foliation of the conglomerate and that is interpreted to pre-date conglomerate deposition. The pebbles are several centimetres to several tens of centimetres in length and appear round where less deformed. Toward the west, the pebbles become smaller and the percentage of arkosic matrix increases. Finally, the matrix-supported conglomerate grades into arkosic sandstone, which is intruded by the Black Brook Granitic Suite to the west. At the contact is a layer about 30 cm thick, rich in muscovite and pyrite. Although both the McMillan Flowage Formation and the Cheticamp Lake Metamorphic Suite are strongly deformed, no significant concentration of deformation is observed along the contact. The contact appears to be primary (depositional).

The Cheticamp Lake Metamorphic Suite and the McMillan Flowage Formation are typical of the Aspy and the Bras d'Or terranes, respectively. Because the pebbles in the conglomerate contain a pre-depositional fabric and the sedimentary rocks are arkosic, it is possible that their source is in the Grenville basement. Considering that the Bras d'Or terrane has the nature of an island arc (Raeside and Barr, 1990), it is possible that the Aspy terrane represents a back-arc basin between the arc and the Grenville basement. The lithology of the terrane is consistent with such an interpretation.

Recent field work has revealed a significant east-over-west dip-slip movement on the Eastern Highlands shear zone in Silurian to Early Devonian time, before the Late Devonian to Early Carboniferous oblique dextral movement. This dip-slip movement may be the result of closure of the back-arc basin. However, the Eastern Highlands Shear Zone, which lies between the Aspy and Bras d'Or terranes, is not necessarily the exact boundary between the basin and the arc.

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A RE-INTERPRETATION OF THE BATEMAN BROOK METAMORPHIC SUITE, CAPE BRETON HIGHLANDS, NOVA SCOTIA: SHEARED, FAULT-BOUNDED BLOCKS OF OTHER UNITS[1]

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The Bateman Brook Metamorphic Suite, as previously defined, is the westernmost unit of the Bras d'Or terrane in the central Cape Breton Highlands. It outcrops along the Eastern Highlands Shear Zone, the contact between the Bras d'Or terrane and the Aspy terrane to the northwest. The Bateman Brook unit has been reported to contain a wide range of lithologies, and contacts with adjacent units are mainly faulted.

Re-examination of samples and thin sections of rocks from the Bateman Brook Metamorphic Suite shows it to consist of semipelitic to psammitic schist, banded mafic gneiss, and foliated, dioritic, mafic gneiss similar to the adjacent Kathy Road Dioritic Suite. Rocks show two major shear fabrics, (1) an early, intensely foliated and lineated fabric indicative of shear with a high recovery-rate to strain-rate ratio and (2) a later mylonitic fabric indicative of low recovery-rate to strain-rate ratio. The early fabric is more widely distributed and is presumed to have resulted from major motion in the Eastern Highlands Shear Zone. The later fabric is interpreted to have formed during movement on subordinate, later faults.

As a result of this study, the Bateman Brook Metamorphic Suite is an abandoned unit. The southern part of the suite, which consists mainly of schist and includes a distinctive quartz-muscovite schist, is re-assigned to the Sarach Brook Metamorphic Suite of the Aspy terrane. The central section of the Bateman Brook Metamorphic Suite is interpreted to be a mix of foliated Kathy Road Dioritic Suite (located to the east) and mafic to feldspathic gneiss and schist of the Jumping Brook Suite (to the west). The northern part of the Bateman Brook Metamorphic Suite, consisting entirely of semi-pelitic schist and feldspathic gneiss is re-assigned to the Jumping Brook Metamorphic Suite.

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PRELIMINARY KINEMATIC MODEL FOR NEOPROTEROZOIC III DEFORMATION, AVALON COMPOSITE TERRANE, NORTHERN MAINLAND NOVA SCOTIA[1]

J. B. Murphy[2], *J. D. Keppie, R. D. Nance*[3] *and T. R. Stokes*[4]

Geochronological data indicate that Neoproterozoic III volcano-sedimentary arc-related sequences in northern mainland Nova Scotia were deposited and poly-deformed after ca. 618 Ma but before being intruded by gabbroic to granitic plutons at ca. 608 Ma. In the eastern Cobequid Highlands, the contact between the Great Village River Gneiss and Gamble Brook Formation is a ductile shear zone. Kinematic indicators indicate sinistral and normal components of slip attributed to the opening of the basin into which Neoproterozoic III sequences were deposited. The structurally overlying Folly River Formation is deformed by north-verging thrusts and isoclinal folds (Nance and Murphy, 1990). In the western Cobequid Highlands, the Jeffers Group is characterized by a pervasive sub-horizontal to moderately dipping penetrative cleavage, with associated stretching lineation and isoclinal folds attributed to northerly-verging Precambrian thrusts. In the Antigonish Highlands deformation of the Georgeville Group resulted in the development of north-south, easterly-vergent isoclinal folds and thrusts followed by N-S to NE-SW upright folds. The structural style of Neoproterozoic III sequences together with the close temporal association between deposition, deformation and plutonism of these sequences supports a model involving the opening and deformation of strike-slip basins by oblique subduction and translation within a volcanic arc.

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CARBONIFEROUS IGNEOUS ACTIVITY IN THE COBEQUID HIGHLANDS[1]

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Plutons and associated volcanic rocks of latest Devonian to early Carboniferous age in the Cobequid Highlands are the igneous response to a complex tectonic history on the southern margin of the Magdalen basin adjacent to the Cobequid Fault. Recent U-Pb dating by Doig *et al.* suggests that the plutons are of latest Devonian to earliest Carboniferous age. The great extent of dioritic plutonism suggests a pull-apart regime. Subsequent deformation of the plutons and their associated volcanic products (parts of the Fountain Lake Group) suggests Namurian thrusting and Westphalian dextral strike-slip motion on the Cobequid Fault.

Hydrothermal activity in the Cape Chignecto, Hanna Farm, West Moose River and North River plutons has been documented using thin sections, and microprobe and whole-rock analyses. Cross-cutting relationships suggest that albitization of felsic rocks and biotitization of mafic rocks are the earliest alteration events. The biotitization resembles that found in some porphyry copper deposits. Airborne radiometric maps suggest a strong potassium anomaly along the Cobequid Fault, probably related to hydrothermal alteration. Later phases of alteration are represented by veins including chlorite, carbonate, rutile and hematite.

The different phases of another granite pluton - the Pleasant Hills pluton - have been mapped and differentiated petrographically and geochemically. This pluton was emplaced at a high structural level and contains some sub-volcanic rocks.

Work has begun on the contact of the Folly Lake diorite with the Hart Lake - Byers Lake granite. The contact shows complex mutual intrusion of diorite and granite, with evidence for co-existence of mafic and felsic magma.

The Fountain Lake Group north of Cape Chignecto has been partially remapped. It consists of a thick sequence of rhyolite, with lesser basalt and minor sediments. There is no unequivocal evidence that it is of Devono-Carboniferous age. This volcanic sequence has been thrust northward. Intense alteration of the volcanic sequence, including silicification of basalt, appears to postdate this thrusting. A series of geochemically-related late dykes both predate and postdate final thrust motion, and geochemically resemble Carboniferous dykes elsewhere in the Cobequid Highlands. In many cases, dykes have irregular or stoping-type margins, and the largest dykes are tens of metres wide. One dyke cuts an inlier of conglomerate and siltstone. The basalt units in the volcanic succession are geochemically indistinguishable from the dykes, except where affected by silicification.

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KINEMATIC ANALYSIS OF LATE PALEOZOIC DEFORMATION IN THE WESTERN CUMBERLAND BASIN[1]

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The Cumberland Basin is a large (3600 km^2) east-west synclinorium located in northwestern Nova Scotia. Sediments at the centre of the basin are at least 7 km thick (Ryan *et al.*, 1987), suggesting anomalously rapid deposition in comparison with other Devono-Carboniferous basins in the Canadian Appalachians. The basin is bounded to the south by the Cobequid Highlands, to the northwest by the Caledonia Highlands of southern New Brunswick, and to the east by the Scotsburn Anticline.

Upper Devonian to Lower Permian sedimentary rocks of mostly continental origin fill the basin (Ryan *et al.*, 1987) and consist of conglomerate, sandstone, shale, and local but important deposits of coal and evaporites. These sedimentary rocks were deformed by faults and folds prior to the deposition of the Late Westphalian to Stephanian Pictou Group which unconformably overlies the Late Carboniferous Cumberland, Mabou, and Windsor groups in the northern Cumberland Basin.

Major east-west faults include the subparallel Athol, Sand Cove, and Sand River faults, which can be traced across the Cumberland Basin from Springhill to Chignecto Bay (Ryan *et al.*, 1990). The faults become splayed and join smaller north-south faults or die out near Springhill. The westward trace of these fault zones beyond the shoreline of Chignecto Bay is uncertain. Northwestward-trending fault splays are exposed along the shore, but these either die out or are truncated by the sinistral northeast-southwest Harvey-Hopewell Fault in the Caledonia Highlands. Inland exposure of these faults is poor, but analysis of structures elsewhere within the basin, such as those displayed by the Springhill coal seams (Calder, 1984), will be analyzed to provide a kinematic synthesis of the evolution of the Cumberland Basin.

The Athol, Sand Cove and Sand River fault zones outcrop along a 5 km costal section of the Chignecto Bay from Sand River to Clam Cove. These faults deform the Late Carboniferous Ragged Reef Formation of the Cumberland Group which comprises massive coarse conglomerate interbedded with finer grained lithic arenite and thin beds of siltstone and shale that locally contain coalified fossil tree remains. Faulting within this coastal section is predominantly extensional in origin with normal, reverse and strike slip components. Overall displacement across the fault zone is uncertain. Offset along individual normal and reverse faults is usually only a matter of a few metres, although the combined offset across the fault zones may be substantial.

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STRATIGRAPHY, STRUCTURE, METAMORPHISM AND TECTONICS OF THE CAPE NORTH AND MONEY POINT GROUPS, NORTHERN CAPE BRETON HIGHLANDS, NOVA SCOTIA[1]

A. Wunapeera[2] and R. P. Raeside[2]

The Cape North and Money Point groups of the Aspy terrane were mapped in the summer of 1990 and for three weeks in 1991. The area extends from Money Point and Cape North to the headwaters of the North Aspy River on both sides of the Aspy Fault.

Medium- to high-grade metasedimentary rocks include semipelitic, pelitic, and calc-silicate gneiss, with minor amounts of amphibolite, marble and mylonite. Low- to medium-grade rocks include mafic to felsic metavolcanic rocks (amphibolite and hornblende-biotite schist) and metasedimentary rocks (semipelitic, pelitic, and calc-silicate rocks). These rocks have been abundantly intruded by various granitic rocks which range in age from Silurian to Early Carboniferous (?) (e.g. the foliated, late kinematic Gulch Brook granite, unfoliated, post-tectonic Wilkie Sugar Loaf granite, and the Black Brook Granitic Suite).

The low- and high-grade units are deformed and display similar fabric development and late-stage structural effects. The contact between the units is conformable. No major break has been recognized. At least three different phases of folding have been recognized. F_1 folds are moderately inclined to upright isoclinal folds with axial planar cleavage. F_2 folds are upright to gently inclined, close to tight folds, approximately coaxial with F_1 folds. F_3 folds are open to close, with rounded to chevron shapes and numerous sets of associated kink bands.

The metamorphic grade increases rapidly from east to west across the Cape North peninsula. Medium- to high-grade rocks were metamorphosed to upper amphibolite facies (biotite, staurolite, kyanite and sillimanite zones). Low- to medium-grade rocks were metamorphosed at greenschist facies. Mineral assemblages include garnet, biotite and chlorite. In the southwestern part of the area metamorphic grade increases from west to east through staurolite-kyanite, kyanite, to sillimanite zones. Retrograde metamorphism has affected these rocks resulting in the development of large, irregular, coarse grained masses of muscovite, chloritization of micas, and sericitization of feldspars.

Both rock units appear to be Ordovician-Silurian in age. They have been extensively intruded by the varied granitic rocks mentioned above. Many of these show characteristics of crustal-derived plutons and appear to be related to crustal thickening and post-collisional extension.

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MARINE OR NOT? THE SYDNEY COALFIELD, NOVA SCOTIA, CANADA[1]

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The Sydney coalfield, Nova Scotia, is generally regarded as being non-marine, which stems mainly from the work by Dawson and by Bell. Interpretation of data on boron geochemistry gathered by the author over the years from various parts of the Sydney coalfield certainly would support that view. The highest values (20 ppm B) were found in the ash of some coal seams, the lowest (not exceeding 4 ppm B) in epigenetic and syngenetic pyrite samples, limestone from one locality showed intermedite values. It is considered that the magnitude of the boron values cited is too low, as 180 ppm B or more are required to hypothesize marine influences.

Paleozoological evidence, on the other hand, is as yet inconsistent. What the fossil record does not categorically preclude is evidence for marine influences. For example, finds of the remains of crossop-terygian fish from above the Harbour Seam are inconclusive, as the piscine taxon was capable of living in either marine or in fresh-water conditions, according to the fossil record in Great Britain. Positive evidence for marine influences in the Sydney coalfield consist of two independent lines of fossil finds. One of them involves agglutinated foraminifera that were repeatedly found throughout the strata in the Sydney coalfield. The other involves representatives of several genera of ostracodes, including that of *Sensabella* spp. Although ostracodes are very common and diversified in the Sydney coalfield, the report of *Sansabella* spp. is new and encouraging. Species of the genus were found by the author in 1990 in at least three separate cannel coal layers approximately 20 m below the Hub Seam (main), in the Point Aconi area. The foraminifera and the ostracodal finds, however, require confirmation through more substantive work and taxonomic study.

I advocate a coordinated effort by geochemists, mineralogists, paleozoologists, physical stratigraphers and other interest groups for a systematic approach to solving the problem of potential marine influences in the Sydney coalfield of Nova Scotia. Results would immediately have implication for the Phanerozoic reconstruction involving the paleogeography of ancestral Cape Breton *vis-a-vis* that of ancestral Europe. Thus, Carboniferous palaeogeographic and palaeobiogeographic purposes are served.

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MULTIPARAMETER BOREHOLE GEOPHYSICAL MEASUREMENTS IN TIN EXPLORATION AND DEVELOPMENT HOLES[1]

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Using the Geological Survey of Canada R&D logging system, twelve parameters were recorded from five runs in holes drilled for exploration and for mine development at several locations in southern Nova Scotia. The borehole geophysical measurements have been correlated with geological logs and assays to determine which parameters could provide information useful for future exploration and development.

The parameters logged include: magnetic susceptibility, natural gamma ray spectrometry, IP, resistivity, self potential, temperature and T gradient, and spectral gamma-gamma which relates to heavy element content and density. Variations in these parameters relate to changes in lithology, mineralization or alteration as well as to the presence of features such as fractures. Examples of logs will be presented, illustrating their utility and the information which can be extracted relative to the occurrence of tin in Nova Scotia.

1 Project carried by the Geological Survey of Canada under the Canada - Nova Scotia Cooperation Agreement on Mineral Development 1990-1992

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DRIFT PROSPECTING IN THE MIRA - FRAMBOISE AREA, CAPE BRETON ISLAND, NOVA SCOTIA[1]

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Reconnaissance and detailed till sampling was completed in the Mira (NTS 11F/16) and Framboise (11F/9) areas during the 1991 field season to complement the limited till sampling program carried out in 1990. Soil and till samples collected at the Yava, Deep Cove, MacIntyre Lake, Copper Shaft, and Blue Mountain (MacDonald Lake) occurrences show high metal levels in the <0.063 mm size fraction. Much of the metal has been mobilized out of the B horizon, partly into the C horizon and partly into groundwater and streams. In the Blue Mountain area the high metal content of the black argillite is strongly reflected in the till. At Deep Cove there is Ba enrichment but only 'spotty' enrichment of Mo. Intriguing Au levels were obtained from the Copper Shaft, MacIntyre Lake and Blue Mountain sites. In 1991, approximately 600 till samples were collected from across the area and analysis of the <0.063 mm fraction is under way, which will be followed by analysis of the heavy mineral and pebble fractions from selected samples. One half of the till samples were collected from surface pits (3 to 5 km apart) that correspond to regional biogeochemical sample sites, also sampled in 1991. These till samples were collected to establish regional geochemical background values for drift prospecting for base metals and gold, and to identify anomalous areas that may indicate mineralized bedrock nearby.

In 1991, about 170 surface till samples were collected from detailed sampling grids around the Mindamar mine (Zn-Pb-Cu) at Stirling, the Deep Cove occurrence (Mo-Ag-Bi-Cu), and the Blue Mountain occurrence (Pb-Zn). This work will document the nature of glacial dispersal from the mineralized sources: that is, the directions and distances that successive ice flow events have dispersed material, and the geochemical signature reflected in tills. Approximately 130 fresh till samples were collected from coastal sections around Gabarus Bay and at several locations as far south as St. Esprit Beach. These samples were collected to document shifts in till provenance and ice flow patterns. In all sections most of the sediment consists of a red, clay-rich till that contains a mixture of local and distantly derived clasts. The red colour and fine-grained texture of this till is the result of erosion of Carboniferous sedimentary rocks lying to the west of the study area. In the southern part of the area, the red, clay-rich till is overlain by a buff-grey, sandy till, varying in thickness from less than 0.5 m in the Stirling area to 5.0 m at Capelin Cove and St. Esprit Beach. This sandy till contains clasts mainly of local origin. Till fabric data indicate that the red, clay-rich till was deposited by ice flowing eastward and was subsequently remolded by north-northeastward flowing ice. The sandy till cap was probably deposited by ice flowing northward. These two phases of ice flow are recorded by striae on numerous outcrops exposed along the coast.

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RECONNAISSANCE BIOGEOCHEMICAL SURVEYS IN SOUTHWESTERN NOVA SCOTIA AND CAPE BRETON ISLAND[1]

C. E. Dunn[2] and S. W. Adcock[2]

Between early May and mid-June 1991, two biogeochemical surveys were conducted in Nova Scotia. The first covered approximately 5500 km^2 in the southwest bounded by a line extending from 50 km north of Yarmouth, eastward to Lake Rossignol, and south to Liverpool. Samples were collected from approximately 550 sites, thereby providing an average sample density of 1 per 10 km^2. For most of the survey area sample density was approximately 1 per 8 km^2, with fewer samples in areas of difficult access south of East Kemptville. Some helicopter assistance provided access to part of this area.

The Cape Breton survey covered the southeastern corner of Cape Breton Island. The northern limit extended from near Glace Bay, southwestward along St. Andrew's Channel to Lake Bras d'Or, then southward to St. Peters. Within this 4000 km^2 area samples were obtained from more than 550 sites, providing a sample density of 1 per 7 km^2. Limited helicopter support permitted access to some remote areas.

The desired sample media for each site were twigs and outer bark of spruce (red spruce, *Picea rubens*, from the southwest; or black spruce, *Picea mariana*, from Cape Breton); twigs and outer bark of tamarack (*Larix laricina*), and twigs of Balsam fir (*Abies balsamea*). This selection was based on the availability of common trees, and on analytical data obtained from an orientation survey (October 1990) to determine which tissue types yield the best response to known mineralization in the areas. For the southwest Nova Scotia survey, the total number of tissue samples collected was approximately 2000, since tamarack was not present at all sites. In southeast Cape Breton Island, there is greater floral diversity, such that Balsam fir is the most widespread species, and the total number of samples was approximately 1700.

All samples were shipped to the Geological Survey of Canada laboratories for sample preparation. After air-drying, the needles were separated from the twigs, and all twig and bark samples were ashed in a kiln at 470°C for 24 hours. The analytical program involves instrumental neutron activation analysis (INAA) for 35 elements at Activation Laboratories Ltd. (Ancaster, Ontario), and inductively-coupled plasma emission spectrometry (ICP-ES) for 31 elements at Min-En Laboratories Ltd. (Vancouver).

Preliminary data show enrichment of Sn, W, As, Sb, Bi, Li, Cs, Se, Ta, and U in samples from the East Kemptville area, and high base metal concentrations in several parts of southeast Cape Breton Island. Gold levels are slightly higher in bark samples from southwest Nova Scotia than in those from Cape Breton.

1 Funded by Geological Survey of Canada under the Canada - Nova Scotia Cooperation Agreement on Mineral Development 1990-1992
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AIRBORNE GAMMA RAY SPECTROMETRY/TOTAL FIELD MAGNETIC/VLF-EM SURVEYS, CAPE BRETON ISLAND AND MAINLAND NOVA SCOTIA[1]

K. L. Ford[2], P. B. Holman[2], J. A. Grant[2], J. M. Carson[2] and R. Hetu[2]

Under the Canada - Nova Scotia Cooperation Agreement on Mineral Development (1990-1992) 12,000 line km of airborne gamma ray spectrometric/total field magnetic/VLF-EM data were acquired in the fall of 1990 using the Geological Survey of Canada Skyvan aircraft at a line spacing of 1 km. Areas surveyed include: (1) northern Cape Breton Highlands, north of 46°37'30"; (2) Bras d'Or Lake-Sydney area, southern Cape Breton Island, and four smaller fill-in surveys in the Amherst, Greenwood, Digby and Dartmouth areas.

These surveys complete the regional (1 km line spacing) airborne gamma ray spectrometric coverage of the province. Survey results have been added to the provincial database and published as Geological Survey of Canada Open File 2375 *Radioactivity Maps of Nova Scotia* at 1:2 000 000 scale. Survey results are also available as digital profile and gridded data. Surveys flown prior to 1990 are available as 1:50 000 scale black line contour maps and stacked profiles. In addition, data acquired prior to 1990 have been compiled into a set of eight, 1:500 000 scale colour maps (Geological Survey of Canada Map 35006G) published in 1989.

Follow-up studies in several areas of the province (Ford *et al.*, 1989) have demonstrated that airborne gamma ray spectrometry can be a valuable aid to regional and detailed bedrock and surficial geological mapping and mineral exploration. It has been shown that these surveys are an excellent predictive tool for mapping not only surficial geology but also bedrock geology where radioelement concentrations vary in response to magmatic metasomatism and hydrothermal alteration.

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1 Funded by Geological Survey of Canada under the Canada - Nova Scotia Cooperation Agreement on Mineral Development 1990-1992

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DEFORMATION AND METALLOGENESIS IN THE ACADIAN OROGEN, CENTRAL CAPE BRETON HIGHLANDS, NOVA SCOTIA[1]

G. Lynch[2] and C. Tremblay[2]

Deformation within the Acadian orogen of the central Cape Breton Highlands features: (a) mid-crustal west-vergent imbricate thrusting within the Jumping Brook complex; (b) opposite-facing reverse fault systems which displace deep crustal rocks of high metamorphic grade over medium- to low-grade volcanic arc assemblages; and (c) late extension. Refinement of the tectonic context for the region helps to better classify existing mineral occurrences and may direct exploration toward new possibilities.

Imbricate thrusting within the Jumping Brook complex is marked by structural repetitions of a turbiditic sequence and an associated metavolcanic assemblage. The footwall to hanging wall transition of the westernmost exposed thrust corresponds to the greenschist to amphibolite facies transition, and with the almandine isograd. The eastern boundary of the Jumping Brook complex is truncated by a west-directed reverse fault which separates it from high grade orthogneiss of the Pleasant Bay complex. Syn-kinematic staurolite is a distinctive feature of this fault, and occurs in pelitic members of the immediate footwall. Farther to the east, east-directed reverse faulting along the Eastern Highlands Shear Zone juxtaposes high grade gneissic rocks against low grade supracrustal volcanic arc assemblages. This shear zone also contains associated staurolite, and is mylonitic and strongly folded, possibly having been deformed by the west-verging faults.

Elements of extensional tectonics are well developed in the west within the Jumping Brook complex and surrounding rocks. These include moderate to shallow-dipping mylonite zones which have a domed distribution. The mylonites merge with, and are rooted in, the earlier-formed thrust and reverse faults which appear to have been re-activated during this later phase of deformation. Available kinematic indicators, mineral lineations and kink bands indicate a predominantly northward movement of the upper sheets during extension. Denudation is further demonstrated by sedimentation and deposition of volcanic rocks from the Upper Devonian Fisset Brook Formation upon units situated at the lowermost structural levels.

Three broad classes of mineralization are recognized: (1) sheared volcanic-hosted polymetallic sulphide lenses of likely primary exhalative origin, (2) mesothermal Au-quartz veins related to folding and reverse faulting, and (3) late-orogenic (extension) magmatic systems including porphyry stockworks and potentially epithermal mineralization.

1 Contribution to the Canada - Nova Scotia Cooperation Agreement on Mineral Development 1990-1992. Project carried by the Geological Survey of Canada

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A NEW LOOK AT THE FRENCH ROAD COPPER OCCURRENCES, CAPE BRETON ISLAND: A PRELIMINARY REPORT[1]

A. L. Sangster[2]

Small units of pyrrhotite-chalcopyrite skarn near French Road, in the Gabarus Bay area, occur in a calcareous horizon in a Cambrian transgressive rock sequence consisting of basal redbeds and quartzite that pass upward through grey-green argillite and a thin, calcareous redbed sequence into sulphidic, carbonaceous black argillite (Barr *et al.*, this volume). The black argillite is pyrrhotitic and contains strongly anomalous (thousands of ppm) Zn and Pb. The skarns occur within a large thermal aureole that is believed to be associated with an unexposed intrusion of assumed Devonian age. Small granite porphyry dykes of Devonian age are exposed locally within the limits of the aureole.

The occurrences have generally been attributed to hydrothermal processes related to Acadian granites similar to those at the nearby, porphyry-type Deep Cove and Gillis Mountain occurrences (Mo-Ag-Bi) and Eagle Head vein (Bi). However, the marine transgressive environment reflected by these Cambrian sedimentary rocks is a common setting for sedimentary copper deposits, permitting the speculation that the Blue Mountain and Copper Shaft occurrences may contain sulphides that predate Acadian plutonism and/or may have been derived from redbed brines mobilized during Acadian plutonism. The potential of a genetic affiliation for the skarns with redbeds is indicated by the mapping of Barr *et al.* (this volume) who correlate a nodular calc-silicate horizon and skarns within the contact aureole, with a thin, calcareous, red argillite horizon within strata composed dominantly of green argillite outside the aureole.

Lead isotopic analyses on galena are as follows:

LOCATION	SAMPLE TYPE	206/204	207/204	208/204
COPPER SHAFT	Galena from skarn	18.258	15.592	38.043
COPPER SHAFT	Galena from skarn nodule in grey argillite	18.289	15.607	38.096
BLUE MOUNTAIN	Galena coating fracture in black argillite	18.261	15.604	38.141
McINTYRE LAKE	Galena coating fracture in quartzite	18.268	15.605	38.097
EAGLE HEAD*	Vein?	18.308	15.628	38.086

The Blue Mountain galena samples are less radiogenic than Bi-bearing veins at Eagle Head, with which they have been correlated, suggesting a component of less radiogenic lead, possibly from the host sedimentary rocks.

The $\delta^{34}S_{po}$ from skarn and calc-silicate nodule sulphides from the Copper Shaft area is 4.2 to 4.9‰ (5 samples). The $\delta^{34}S_{po\text{-}py}$ for sedimentary rocks in the Copper Shaft, Blue Mountain and MacDonald Lake areas ranges between -6.1 and +12.7‰ (15 samples) with an indication of a stratigraphic variation in the isotopic composition of sulphur. These data permit interpretations for a sulphur source within the enclosing sedimentary rocks but do not exclude a magmatic origin.

Ongoing work will include broad spectrum chemical analyses of skarn and host rocks and additional lead and sulphur isotopic analyses to provide constraints on different metal sources for both skarn (Cu) and black argillite (Zn-Pb) units.

1 Funded by Geological Survey of Canada under the Canada - Nova Scotia Cooperation Agreement on Mineral Developement 1990-1992

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* Average of 2 analyses courtesy R. Thorpe

EARLY DOLOMITIZATION OF THE GAYS RIVER FORMATION IN THE SHUBENACADIE AND MUSQUODOBOIT SUB-BASINS, NOVA SCOTIA[1]

M. M. Savard[2]

The Gays River Formation is a dolomitic horizon which lies between clastic rocks of the underlying Meguma Group and younger evaporites of the Carrolls Corner Formation. In the Shubenacadie and Musquodoboit sub-basins of mainland Nova Scotia, the dolostones cover a combined area of 6000 km^2 and vary from 3 to 50 m in thickness. The Gays River Pb-Zn deposit occurs along a 250 m basement high separating the two sub-basins.

Two types of dolomite compose the bulk of the dolostones: early, anhedral, replacive micro-dolomite and coarser, pore-filling rhombohedrons. Paragenetically, the replacive dolomitization occurred after marine cementation and before micro-brecciation, micro-fracturing, mineralization, calcite cementation and stylolitization. Textures observed by SEM indicate at least partial recrystallization of the replacive dolomite, whereas the perfectly rhombohedral, pore-filling dolomite undeniably postdates the corrosion.

The replacive dolomite has $\delta^{18}O$ values as low as -9‰ (relative to PDB standard) which is markedly lower than that for the estimated marine dolomite for the Viséan age (approximately 0 to +4‰ relative to PDB), and even lower than the theoretical signal of mixed-water dolomites (-4 to -6‰). Their ^{87}Sr-^{86}Sr ratios (0.7080) are slightly more radiogenic than the Viséan marine signal (0.7075-0.7079). Moreover, their 0.3 to 1.1 weight % of Fe and 0.1 to 0.4 weight % of Mn are much higher than the average contents of modern surficial dolomites.

The pore-filling dolomites are noticeably enriched in Fe and Mn: 0.8 to 2.2 and 0.4 to 1.4 weight % for Fe and Mn, respectively. Such high values are commonly measured in hydrothermal dolomites around basemetal deposits. Unfortunately, because they only form fine layers, the pore-filling dolomites have not yet been investigated for isotopic tracers.

In former studies, a close association of dolostones to evaporites and local evidence of solution were used to advocate both evaporitic and mixed dolomitization models. However, dolomite geochemistry does not support a single-step dolomitization by hypersaline or mixed waters. Sr and ^{18}O depletion, and Fe and Mn enrichment suggest direct dolomitization or re-equilibration of early replacive dolomites by hot (?) fluids. These same fluids could be responsible for precipitation of the less abundant pore-filling dolomites. Further fluid inclusion study will help to test the above suggestions.

1 Project funded by Geological Survey of Canada
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DATA INTEGRATION AND MINERAL POTENTIAL MODELLING IN THE CAPE BRETON HIGHLANDS[1]

G. P. Watson[2], *M. D. de Vries*[3] *and T. Webster*[3]

Integration of multiple geoscience data sets using a PC-based geographic information system (GIS) was carried out to study and interpret the geology of the Cape Breton Highlands, Nova Scotia. A preliminary geological base for the study area was digitized from a 1:500 000 scale provincial map, mineral occurrences taken from CANMINDEX files, regional geochemistry data, conventional topographic information extracted from 1:250 000 scale Surveys and Mapping sector SIF format data (including contoured elevation data, point elevation data, lakes and streams and major road networks) and LANDSAT TM satellite imagery.

The topographic information was used to create a digital elevation model of raw interpolated values, slope and aspect ratio maps, and a three-dimensional perspective model of the area. The latter will be used to display other database layers as 'drapes' over the elevation model. Construction of the digital elevation model was performed on the PRIME-based ARC/INFO system.

Image processing was conducted on two levels. Initially the entire LANDSAT scene, consisting of much of the northern part of Cape Breton Island, was enhanced as classified on the ARIES DIPIX image processing system. This was followed by a more detailed examination which included classification and a geological examination of a sub-area. Image analysis was conducted on both the ARIES DIPIX II and EASI/PACE image analysis systems.

Interpolated maps from the provincial regional geochemical surveys have been created and trend surface analysis was conducted for Zn, Cu and Ag. Work continues for the remaining elements. Cross-tabulation maps of geochemistry with respect to bedrock geology have also been created for these elements and are in progress for other elements.

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